ILLUMINATING ENGINEERING

MARCH 1955

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Daylighting Design Calculations
IES Guide to Photometry
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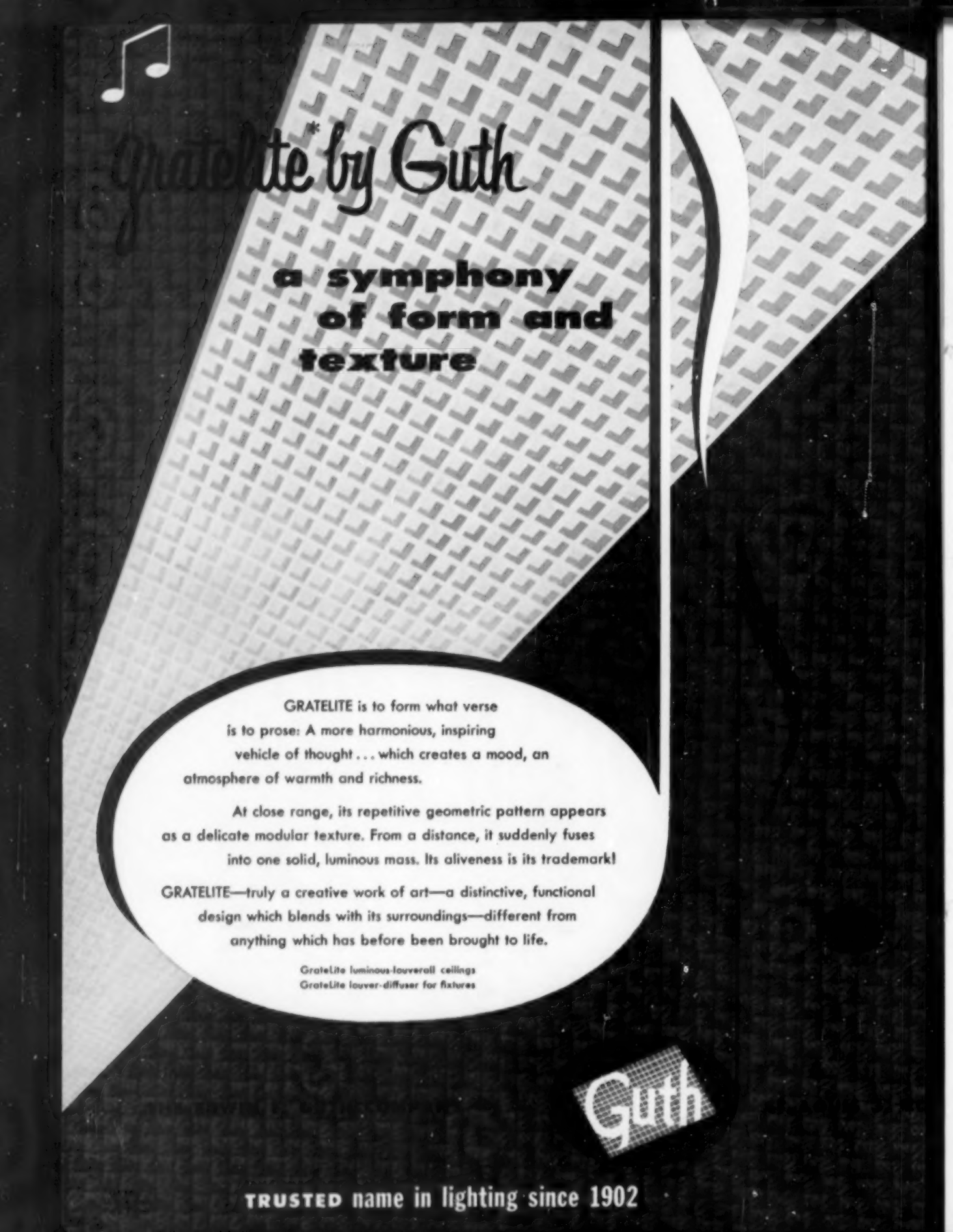
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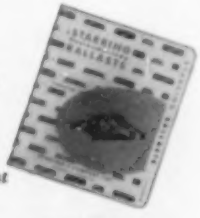

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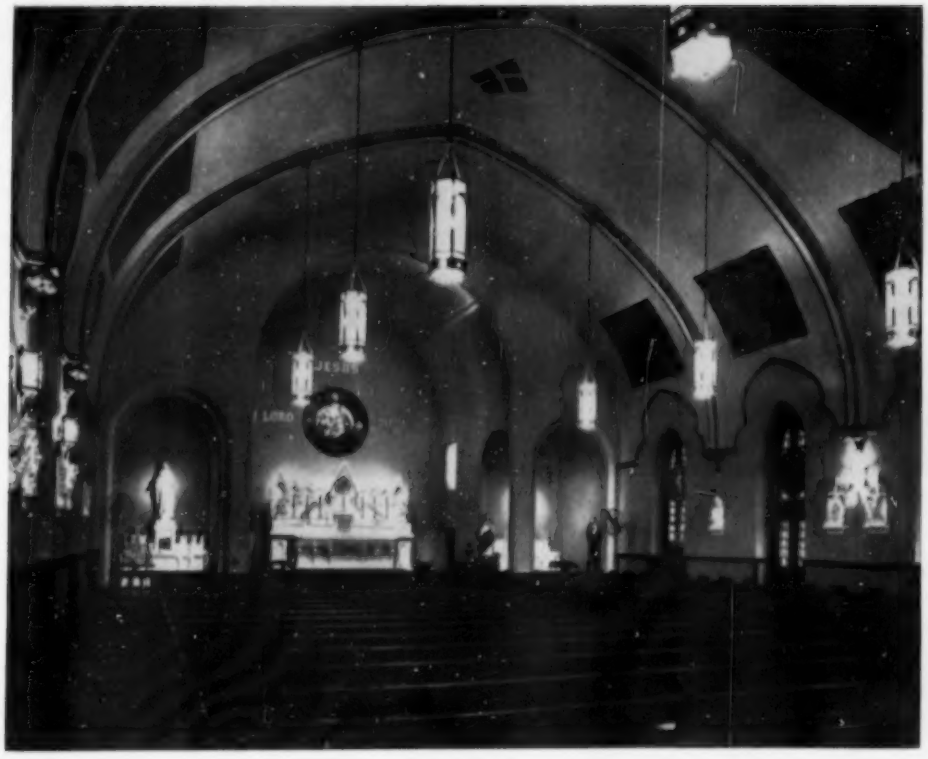


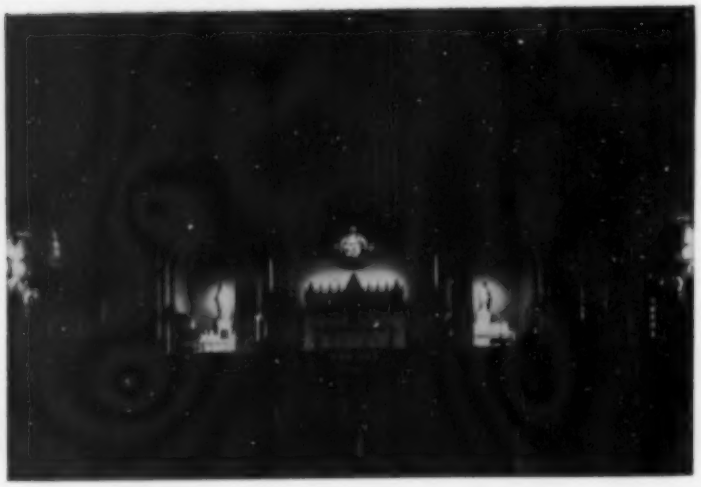
Light for Seeing Principles in an Ecclesiastical Design

THERE is a curious satisfaction in adhering to principle — whether ecclesiastical or temporal. At any rate, such was the experience of Gerald E. Parks (Metropolitan Edison Company, Reading, Pa.) in the relighting of St. Joseph's Roman Catholic Church in Reading.

The old lighting equipment was, of course, replaced in the new lighting plans. In line with principles of lighting application, however, this was almost incidental to overall plans ,and especially surface colors. In order to receive any benefit from the new equipment, the church interior was entirely redecorated according to color plans arrived at by a two-man team of lighting engineer and interior decorator. The old dark brown ceiling gave way to a delightful gray-rose finish, which in addition to better reflectance also achieved a sense of "raising" the ceiling toward infinity. The chancel area when refinished was a light blue color which afforded a beautiful contrast to the all-white altars.

It was the wish of all concerned to retain traditional ecclesiastical elements in the lighting equipment — but with modern results in their performance. True Gothic design, which is traditionally direct lighting supplemented with natural lighting from huge side windows, was the aim of the lighting design.

For general lighting, lantern-type luminaires were suspended from the gracefully curved ceiling. These employed 500-watt incandescent downlights with the proper distribution and shielding. Three 150-watt incandescent lamps located in the center of the lantern body produced an elegant glowing



Switching system provides individual circuits, making 44 different lighting combinations available. The amount of illumination is keyed to type of service and the amount of reading and singing done by the congregation. Here only altar lighting and side urns are used.

effect through the golden-colored etched glass. Upward light from these luminaires was provided by an additional 300-watt incandescent lamp in a wide angle reflector incorporated in each lantern. This upward component added appreciably to the quality of the general lighting, especially during evening services after dark. Each of these light sources was wired on independent circuits.

Side urns corresponding in appearance and design were mounted on both side walls. Matching ceiling-mounted units were located under the balcony area and entrance areas. With all components on, twenty-four footcandles are in service as general lighting in the auditorium area.

Chancel Area

Attraction lighting was purposely planned for the chancel area. To create a stage-like atmosphere, concentrating floodlights of the R-40 type were used on the ceiling behind the natural valance. This incandescent punch brings to life the entire main altar area. As an added thought, to make this center altar still more prominent, strips of 40-watt fluorescent lamps were located in the rear of the altar table, illuminating the rear wall and producing a three-dimensional effect. The entire altar now appears to stand out from the rear wall, and attention of the congregation is irresistibly focused on the altar.

Each of the two side altars is illuminated by a single row of vertical strip using 40-watt fluorescent lamps and highlighted with one R-40 floodlamp directed to the altar itself. In order to accent the statues above each altar, one R-40 spotlamp was directed to the body of the statue, and one R-40 floodlamp was directed to the outside wall. Reflected light from this sidewall reduces all harsh shadows on the image. With one side of the statue illuminated by direct lighting of high intensity and the other side with soft diffuse lighting, the image became more life-like than ever before.

Switching System

Flexibility of lighting control was considered, but since level of illumination need not change during a normal service, no dimming mechanism was planned. There are different types of services, however, so separate and individual circuits were installed. As any service may change so can the lighting. The forty-four different lighting combinations available are controlled by a simple switching system located near the main altar. The amount of illumination provided in the main auditorium is keyed to the amount of reading and singing done by the congregation.

For the lighting engineer, Church officials and congregation alike, success of the installation lies in its retention of well-loved church atmosphere, at the same time providing lighting which exceeds today's requirements for good church lighting.

A Modified Lumen Method of Daylighting Design

By J. W. GRIFFITH
W. J. ARNER
E. W. CONOVER

This paper presents a modification and continuation of a lumen method of daylighting design for predicting illumination on the work plane of interiors presented at the National Technical Conference of the Illuminating Engineering Society in 1952.[1] It is a result of the continuation of the Daylight Study Project at Southern Methodist Universiy sponsored by the Detroit Steel Products Company and the Libbey-Owens-Ford Glass Company.

THE purpose of a prediction technique in daylighting design is twofold. The greatest advantage in having an adequate prediction technique is the possibility of studying alternatives of design for daylighting while plans are still on the drafting table. The architect can predict illumination within a room for varying conditions and ascertain which would be more advantageous in a particular building. He can weigh the advantages of clerestory and bilateral design with that of unilateral design or he may determine the advantages of various ceiling heights on the illumination within the room. After a design has been chosen the architect can weigh the advantages of various surface reflectances within a room which also will assist him in designing a compatible artificial lighting installation. The other main advantage is to be able to predict a value for the illumination within a room under a specific set of conditions. This is somewhat more difficult than comparing alternatives of design since all the interior and exterior conditions of the proposed installation must be obtained and taken into consideration. If the exact conditions are not used in the prediction technique, the results will not give the correct answer.

In comparing predicted results with measured values in existing installations, the engineer must use a proper testing technique so as to insure accurate recording of exterior conditions simultaneously with interior readings. By taking only one exterior reading of the vertical illumination on a window, combining the illumination from the sky and ground, and comparing this with a prediction based on illumination from the sky alone; a variation of 100 per cent can easily result.

The prediction of illumination within a room employing daylight as a source is far more complex than the prediction of illumination from artificial lighting. There are many more variables that must be taken into account in developing daylighting prediction methods. It is practically impossible to include all of these variables in a theoretical approach to the problem. However, in the past 25 years there have been several approaches to theoretical lumen methods of daylighting design.[2] In simplifying the problem for theoretical analysis, many of the variables have been neglected. The authors of this paper believe that all of the variables must be taken into account before a prediction method of daylighting design can be of practical value to the architect and illuminating engineer. With this in mind, it was decided that an empirical approach to developing a daylighting prediction method would be a far more direct approach. Furthermore, it was felt that a method of daylighting design based on empirical data would be easier to comprehend and use, than would a rigorous mathematical analysis even if it were possible to include the many variables affecting daylighting design.

In studying the problem of predicting daylighting within the room the variables were broken down into eight basic categories.

1. The Source

The primary source of daylight is the sun. Where the sunlight is incident on the fenestration and is not diffused the interior illumination distribution from the sun must be computed separately. Since the illumination distribution within the room will vary with both the solar azimuth and altitude as well as intensity it is necessary to predict for specific conditions.

A second source is the sky-brightness pattern above the horizontal as viewed from the fenestration area. This includes sky conditions such as clear, overcast, uniform, partly cloudy, and reflections from obstructions. In predicting illumination from

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 13-17, 1954, Atlantic City, N. J. AUTHORS: Director, Daylighting Research, Southern Methodist University, Dallas, Texas; Research Department, Libbey-Owens-Ford Glass Co., Toledo, Ohio; and Research Engineer, Detroit Steel Products Co., Detroit, Mich., respectively.

a sky brightness pattern it is necessary to consider the distribution from a clear sky and an overcast sky. Since many prediction techniques have been based on a uniform sky, curves for such a condition are given in this paper. A clear sky pattern similar to that shown on the right side of Figure C-4 page 25 of the Recommended Practice of Daylighting[3] was used to develop the clear sky curves. To develop those for overcast skies a brightness pattern similar to that shown on the right side of Figure C-7 page 25 was used. It is quite evident from the curves that the different sky patterns produce different illumination distributions within the room. It is also quite obvious that for equal intensities of incident illumination from the clear sky pattern and the overcast sky pattern that the clear sky would produce higher values of illumination in the interior of the room where the minimum values of a unilateral design are found and lower values of illumination over near the fenestration where maximum values are found. This is due to the fact that the brighter portion of the sky is at the horizon of the clear sky pattern and is projected further into the room. Conversely, the maximum values near the fenestration are higher for the overcast skies and the minimum values in the interior of the room are lower. At the horizon the brightness for the clear sky is considerably higher than that for an overcast sky when compared for equal intensities of illumination on the fenestration and it is quite evident that the utilization of inter-reflected illumination is much higher for the clear sky pattern.

The partly cloudy sky pattern is a combination of clear sky and overcast sky patterns. It is constantly changing and, consequently, it is very difficult to assume exterior conditions for predicting illumination from this type of sky. Since the partly cloudy sky is a combination of the two sky patterns, it is believed that any installation designed to produce adequate illumination from both the clear sky and overcast sky will consequently produce desirable results for most partly cloudy skies.

A third source is the brightness pattern below the horizontal as viewed from the fenestration, commonly referred to as the ground brightness. This takes into account the illumination reflected from the ground and/or roofs, etc., that are below the normal to the fenestration. The curves in this paper are based on uniform ground brightness and, where the brightness pattern does not vary over a wide range, the average ground brightness can be used to compute the illumination from below the horizon. In cases where a deep shadow or an area of considerably high brightness is near the fenestration a weighted average brightness must be used. All of the work plane illumination from the ground is obtained by interreflection. Consequently, the higher the reflectance of the walls and the ceiling the greater the utilization of ground reflectance. On overcast days the brightness below the horizontal will approach the brightness of the sky as a limit. When the average ground reflectance is very high as with snow cover or large concrete areas around a building and controls such as horizontal louvers or overhangs are used, the illumination from the ground can be utilized to produce a large percentage of the illumination on the work plane. For clear sky conditions the brightness below the horizon is of even greater importance. Frequently the brightness below the horizon will be greater than that above for clear sky conditions when the sun is not on the fenestration.

Any obstructions outside the fenestration can be taken into account in the daylighting predictions by using weighted brightness patterns above and below the horizon. In weighting the brightness patterns one must remember that the obstruction itself has some brightness and, in some cases, may be even brighter than the sky or ground.

2. The Fenestration

The type and location of the fenestration has a tremendous effect upon the distribution of illumination within the rooms. Consequently, it is necessary to develop curves for unilateral, bilateral, clerestory, skylight or any other fenestration design. By drawing a distribution curve of illumination similar to the curves used in the Fenestra Method[4] the illumination curves from various windows may be added together to give the total illumination for multilateral daylighting design.

3. Window Area

The height of the window and its relation to the height of the ceiling of a room affects the distribution of the illumination in the room due to its location above the work plane. The height of the window in conjunction with its length determines the total amount of illumination area when reduced by obstructions such as muntins, mullions and mortar joints. The curves in the paper are based on the main fenestration extending from wall to wall and from a normal sill height of approximately three feet to the ceiling.

4. Transmission of Fenestration

The total lumens transmitted through the fenestration from the source is proportional to the transmission of the fenestration media. The transmission of the fenestration media is for clean glass and another factor must be considered in areas where the dirt collection is severe.

5. Location of Observation Point

In simplifying the prediction technique it was found that the illumination should be predicted for the various brightness patterns and fenestration areas separately. This requires prediction of illumination at several points within the room rather than an average illumination value as used in prediction techniques for artificial illumination. The determination of the average daylight illumination in a room does not locate the point of average daylight illumination which may vary considerably in different rooms and for that reason prediction curves were developed for the following points on a center line perpendicular to the fenestration: maximum point five feet from the fenestration, the mid-point in the room, and a minimum point five feet from the interior wall opposite the fenestration. These points were chosen so that a work plane level of illumination curve could be constructed for addition of multilateral lighting designs.

6. Room Dimensions

The physical dimensions of the room are much more critical in daylighting predictions than for artificial prediction techniques. The depth of the room or width perpendicular to the window determines the location of the mid-point and the minimum point of observation. This dimension has a relatively small effect upon the maximum point of observation near the fenestration area. The length of the room parallel to the window affects the fenestration area and shows up in the total lumens transmitted into the room. The height of the ceiling indirectly affects the area of the fenestration as well as the location of the center of the fenestration area above the work plane. The curves in this paper are based on flat ceilings and if sloping ceilings are employed additional curves must be developed. The amount of inter-reflected light from the ground and the lower horizon is either increased or decreased depending upon the angle of the sloping ceiling with respect to the fenestration area. Thus, if the fenestration area is at the high side of a sloping ceiling, the ceiling will not only reflect a larger percentage of illumination from the ground but it will in addition reflect a portion of the sky brightness.

7. Room Reflectances

The reflectances of the interior surface within a room affect both the amount of illumination on the work plane and its distribution. The reflectance of a flat ceiling in a room has no effect upon the direct component of the sky light or illumination from brightness patterns above the horizontal. However, the amount and distribution of the indirect component of daylighting from the sky as well as the indirect illumination from below the horizon is definitely dependent upon the reflectance of the ceiling. Naturally the higher the reflectance of the ceiling the greater the utilization of any reflected light in the room. For this reason, the curves shown in this paper are based upon a ceiling having an approximate reflection of 85 per cent which is obtainable with flat white paint. Since most floor reflectances do not vary too greatly from 30 per cent this value was used for determining the curves. Small variations in floor reflectances have little effect upon the work plane illumination. Wall reflectances in rooms may vary considerably and for this reason the curves are drawn for walls having a reflectance of 30 per cent and 70 per cent. Values between 30 per cent and 70 per cent can be estimated from these curves by using straight line interpolation. It is impractical to predict the reflectance of furniture or its location in most rooms; therefore, these curves were developed for rooms employing no furniture or decorations.

8. Controls

Figs. 1 through 12 are for fenestrations employing clear glass with no controls. These curves as indicated are applicable to daylighting conditions where the sky is overcast or for clear skies with no sun on the window. Figures 13 through 18 are for fenestration areas having a diffuse distribution. They may be used for fully drawn shade cloth, fiber glass curtains, synthetic shades and for diffusing glasss if their distribution pattern approaches the cosine law of distribution. Additional curves must be developed for controls such as louvers and overhangs above the fenestration, since these controls utilize to a greater extent the reflected illumination from below the horizon. Controls such as reflectors placed under the fenestration increase the average illumination from below the horizon and can be taken into account in the average reflectance of the ground. The curves given for diffuse controls are not applicable to glass blocks because the egg crate louver effect of the mortar joints has not been taken into account.

The preceding variables constitute a rather formidable list. It is quite apparent that all of these are not independent variables, but many are dependent on each other. In developing this prediction technique it has not been practical to consider each of the dependent variables separately. Wherever possible the dependent variables are considered together under normal conditions.

Experimental Techniques

The experimental technique used in obtaining additional data for this paper was similar to that

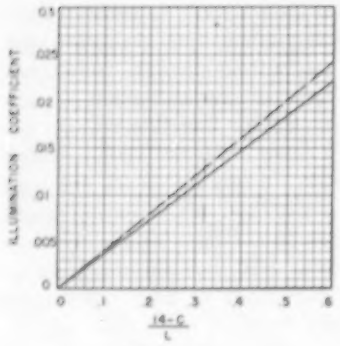
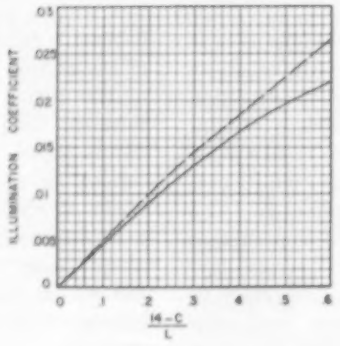


Figure 1.



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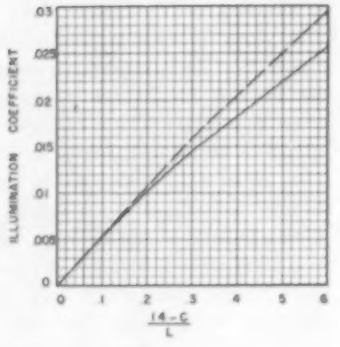
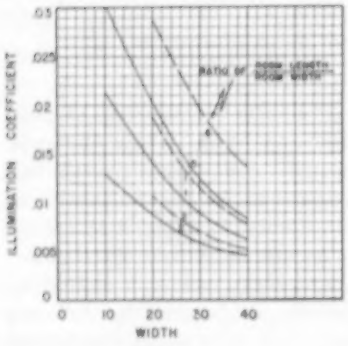


Figure 3.

Curves for determining the Illumination Coefficient of the maximum point. Fig. 1, with light from a clear sky only incident on the main window; Fig. 2, with light from a uniform sky only; Fig. 3, with light from an overcast sky only incident on the main window. Reflection factors: Solid Curve—ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curve—ceiling 85 per cent, walls 70 per cent, floor 30 per cent.



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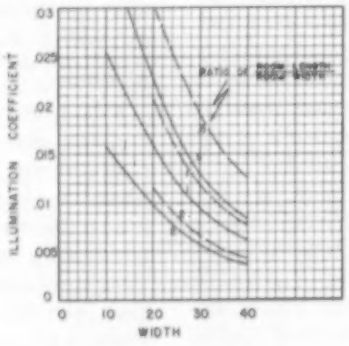

Figure 5.

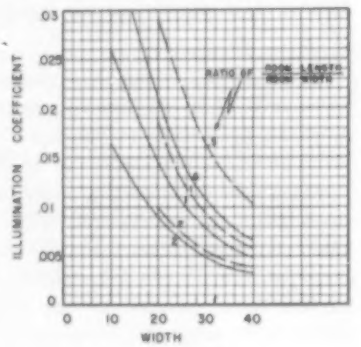

Figure 6.

Curves for determining the Illumination Coefficient of the mid-point. Fig. 4, with light from a clear sky only; Fig. 5, with light from a uniform sky only; Fig. 6, with light from an overcast sky only incident on the main window. Reflection factors: Solid curves — ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curves — ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

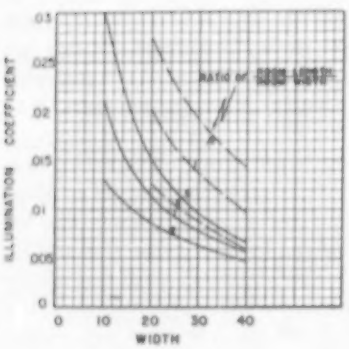

Figure 7.

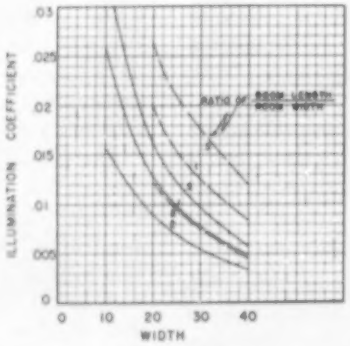

Figure 8.

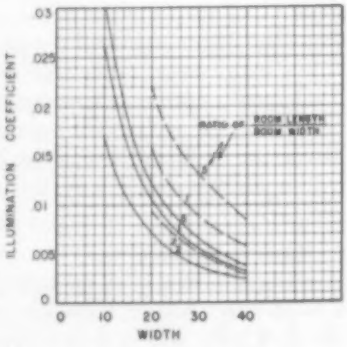

Figure 9.

Curves for determining the Illumination Coefficient of the minimum point. Fig. 7, with light from a clear sky; Fig. 8, with light from a uniform sky; Fig. 9, with light from an overcast sky only incident on the main window. Reflection factors: Solid Curves — ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curves — ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

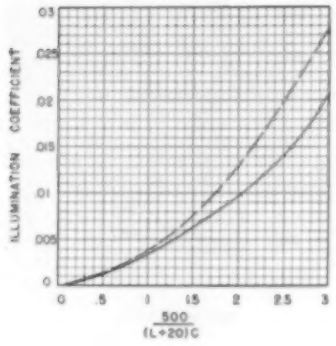

Figure 10.

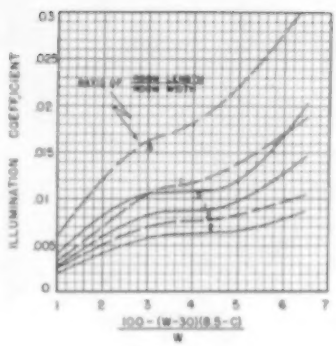

Figure 11.

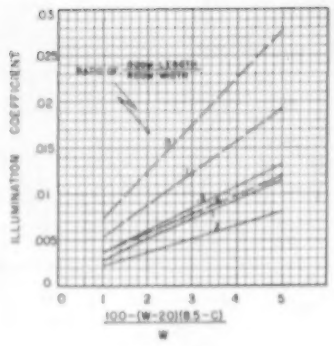

Figure 12.

Curves for determining the Illumination Coefficient. Fig. 10, of the maximum point with light from a uniform ground; Fig. 11, of the midpoint with light from a uniform ground; Fig. 12, of the minimum point with light from a uniform ground only incident on the main window. Reflection factors: Solid Curves — ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curves — ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

outlined in the previous paper entitled *A Lumen Method of Daylighting Design*.[1] Additional tests were run in the artificial sky at the Daylighting Laboratories of Southern Methodist University employing one-twelfth scale models. To insure accuracy in using one-twelfth scale models, a comparison was made between a full size room and a one-twelfth scale model employing the same interior decoration and fenestration as well as identical exterior conditions. This was accomplished by building an exact duplicate of the full size test house at Southern Methodist University and placing it in front of the window of the full scale model. Simultaneous tests were run with the photographic recorder and duplicate readings were obtained throughout the room. Thus it was concluded by careful consideration to all details of a room, a model would give the same results as a full size test room.

All of the model tests were taken with clear glass in the window area. However, for ease of computation, the results were divided by the transmission factor of the clear glass to obtain the curves shown.

Basic Revisions

After further study and testing it was found that the window index concept is not suitable for rooms having ratios of room length to room width other than one. For this reason the window index curves have been dropped from this prediction technique and the illumination coefficient has been plotted against the different variables affecting the particular situation. The room index for artificial illumination was based upon the uniform distribution of illumination at the work plane. Since the work plane diversity varies considerably as the ratio of room length to room width is varied, the index concept for daylighting is not consistant for rooms that are not square. In the Harrison-Anderson methods[5] of predicting artificial illumination there is no difference in the room index of rooms having a ratio room length to width of two or one-half. These rooms are identical since the method requires the placement of the luminaires to be in a symetrical arrangement such that the illumination diversity is less than two. In the daylighting predictions there is considerable difference in a room with a length to width ratio of two and one with a ratio of one-half. A room having a length to width ratio of one-half would be four times as wide or deep as a room having a ratio of two if the lengths of the two rooms were the same.

The curves for the illumination coefficient have been based on a formula which can be expressed as follows:

$$\text{Illumination Coefficient} = \frac{\text{lumens reaching the point of observation on the work plane}}{\text{lumens incident on the nominal window area}} = K$$

This then changes the equation for determining the illumination at a point to:

$$E = \frac{E_i \times A_w \times K \times T_g \times T_w \times M.F.}{D}$$

Where

E = Work Plane Illumination from the source, footcandles

E_i = Illumination Incident on Vertical Windows from the source, footcandles

A_w = Area of masonry opening for window, square feet

K = Illumination Coefficient for Sky, Ground, or diffuse light

T_g = Transmittance of glazing medium for

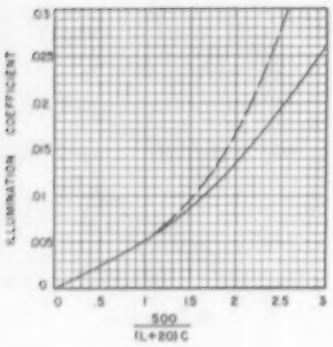

Figure 13.

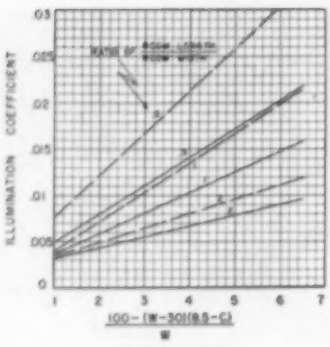

Figure 14.

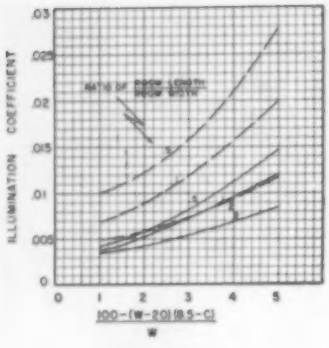

Figure 15.

Curves for determining the Illumination Coefficient. Fig. 13, of the maximum point with light from a diffuse control; Fig. 14, of the mid-point with light from a diffuse control; Fig. 15, of the minimum point with light from a diffuse control only on the main window. Reflection factors: Solid Curves — ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curves — ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

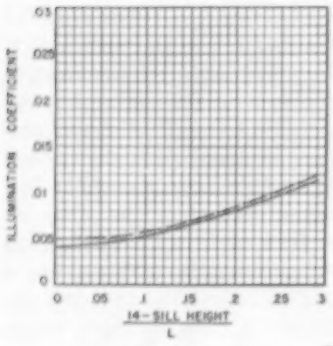

Figure 16.

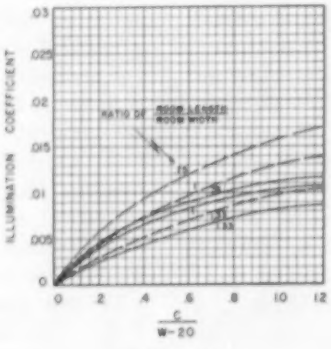

Figure 17.

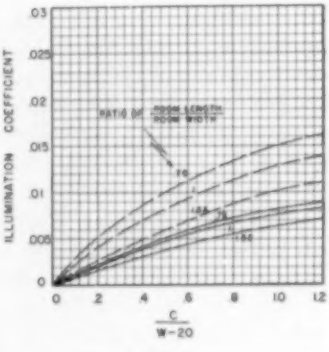

Figure 18.

Curves for determining the Illumination Coefficient. Fig. 16, of the maximum point with light from a diffuse control; Fig. 17, of the mid-point with light from a diffuse control; Fig. 18, of the minimum point with light from a diffuse control only on the bilateral window. Reflection factors: Solid Curves — ceiling 85 per cent, walls 30 per cent, floor 30 per cent. Broken Curves — ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

diffuse incident light (0.8 for clear flat glass)

T_w = Ratio of clear window opening to masonry opening (0.8 for typical metal window construction)

$M.F.$ = Maintenance Factor

D = The perpendicular distance of the point of observation from the window, feet

To determine the illumination at a point from a fenestration employing a diffusing control the transmission factor (T_d) of the control must be included in the numerator of the above equation.

Daylight Performance Data

The data thus far obtained and evaluated are presented in Figs. 1 through 18. These data are the result of several hundred tests and have been reduced to curves varying with the physical dimensions of the room. These curves are used to predict the illumination coefficient or the coefficient of utilization for various observation points under the conditions shown. The solid curves are for rooms having a floor reflectance of 30 per cent, a wall reflectance of 30 per cent and a ceiling reflectance of 85 per cent. The broken line curves are for rooms with a floor reflectance of 30 per cent, a wall reflectance of 70 per cent and a ceiling reflectance of 85 per cent. Where only two curves are shown the coefficient of utilization does not vary appreciably with a change in the room length to room width ratio. In Figs. 1 through 15 where three curves for each wall reflectance are shown the upper curve is for rooms having a length to width ratio of 0.5; the middle curve is for rooms having a length to width ratio of 1; and the lower curve is for rooms having a length to width ratio of 2. In Figs. 17 and 18 the upper curve for each wall re-

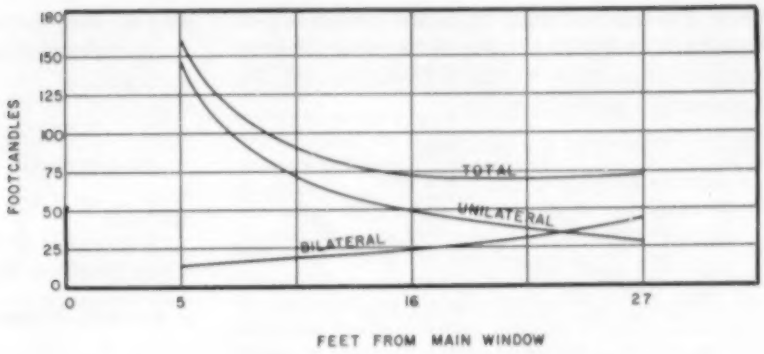

Figure 19. Footcandle distribution graph.

flectance represents a room having a length to width ratio of 0.75; the middle curve a room having a length to width ratio of 1; and the lower curve a room having a length to width ratio of 1.33.

Figs. 1 through 12 contain curves for predicting the coefficient of utilization when clear glass is used as a fenestration media and employing no controls. Figs. 1, 2, and 3 are used for predicting the coefficient of utilization for the maximum value of illumination for clear, uniform, and overcast sky conditions respectively. Figs. 4, 5, and 6 are used to predict the coefficient of utilization for the mid-point in the room and Figs. 7, 8, and 9 are used to predict the coefficient of utilization for the minimum values of illumination for clear, uniform, and overcast skies conditions. Figs. 10, 11, and 12 are used to predict the coefficient of utilization of the maximum, the mid-point, and the minimum value of illumination within the room from a uniform ground or brightness pattern from below the horizon. Figs. 13, 14, and 15 are used to predict the coefficient of utilization for maximum, mid-point and minimum values of illumination from the large window with the normal sill height employing a diffusing control medium. Figs. 16, 17, and 18 are used to predict the coefficient of utilization for the contribution from a 2-ft-9-inch high bilateral window with a diffusing control. In this paper a bilateral window is one in the wall opposite the main window. Its height is measured from the ceiling down.

The curves shown in Figs. 1 through 15 are based on tests of room sizes varying from 10 feet to 40 feet in 10-foot modules with a ceiling height varying from 8 feet to 14 feet in 2-foot modules. The curves in Figs. 16, 17, and 18 are based on tests of room sizes: 30 ft by 30 ft, 30 ft by 40 ft, 40 ft by 40 ft, and 40 ft by 30 ft with 8-ft, 10-ft, 12-ft. and 14-ft ceiling heights. They apply only to bilateral windows using diffusing controls or the equivalent and the transmission factor of these controls must be included in the equation.

The following symbols are used for simplification:

W = the width of the room in feet perpendicular to the window.

L = the length of the room parallel to the window in feet.

D = the perpendicular distance of the point of observation from the window.

C = the height of the center of the window above the floor.

Example

Compute the illumination distribution curve for a 32 ft by 32 ft by 12 ft room with a main window 32 feet long and extending from a 42-inch sill to the ceiling oriented north. Then add to this the illumination distribution curve of a 2 ft 9 inches bilateral window with a sill height of 9 ft 3 inches and 32 feet long oriented south.

Assume the following conditions:

Reflectances
- Floor 30 per cent
- Walls 60 per cent
- Ceiling 85 per cent

Incident Illumination from an overcast sky
- North 500 footcandles total
  - 300 from sky alone
  - 200 from ground alone
- South 572 footcandles total

Controls
- North None
- South 8-foot reflector under the 2 ft 9 inches bilateral window

Transmission Factor
- Glass $T_g = .8$
- Window $T_w = .8$

Maintenance Factor
- $M.F. = 1$

These are conditions similar to those of a test taken at Southern Methodist University March 24,

1950. The reflector under the bilateral window produced a distribution pattern similar to a diffusing control. Since there was no diffusing control, the transmission factor T_d is 1.00.

Step 1 Determine the variables.

$L = 32$ feet
$W = 32$ feet
$C = 7.75$ feet
$A_w = 272$ square feet

$$\frac{500}{(L+20)C} = 1.24$$

$$\frac{14 - C}{L} = .195$$

$$\frac{100 - (W - 30)(8.5 - C)}{W} = 3.08$$

$$\frac{100 - (W - 20)(8.5 - C)}{W} = 2.84$$

Step 2 Determine the Coefficients of utilization.

K_s max. = .0104 from figure 3
K_s mid. = .0080 from figure 6
K_s min. = .0074 from figure 9
K_g max. = .0053 from figure 10
K_g mid. = .0102 from figure 11
K_g min. = .0108 from figure 12

Step 3 Determine the illumination at the maximum, mid, and minimum points from the sky alone.

$$E_s = \frac{E_{is} \times A_w \times K_s \times T_g \times T_w \times M.F.}{D}$$

(a) $$E_s \text{ max.} = \frac{300 \times 272 \times .0104 \times .8 \times .8 \times 1}{5}$$
$$= 108.6 \text{ footcandles}$$

(b) $$E_s \text{ mid.} = \frac{300 \times 272 \times .008 \times .8 \times .8 \times 1}{16}$$
$$= 26.1 \text{ footcandles}$$

(c) $$E_s \text{ min.} = \frac{300 \times 272 \times .0074 \times .8 \times .8 \times 1}{27}$$
$$= 14.3 \text{ footcandles}$$

Step 4 Determine the illumination at the maximum, mid, and minimum points from the ground alone.

$$E_g = \frac{E_{ig} \times A_w \times K_g \times T_g \times T_w \times M.F.}{D}$$

(a) $$E_g \text{ max.} = \frac{200 \times 272 \times .0053 \times .8 \times .8 \times 1}{5}$$
$$= 36.9 \text{ footcandles}$$

(b) $$E_g \text{ mid.} = \frac{200 \times 272 \times .0102 \times .8 \times .8 \times 1}{16}$$
$$= 22.2 \text{ footcandles}$$

(c) $$E_g \text{ min.} = \frac{200 \times 272 \times .0108 \times .8 \times .8 \times 1}{27}$$
$$= 13.9 \text{ footcandles}$$

Step 5 Determine the total illumination at the maximum, mid, and minimum points from the sky and ground.

(a) E_s max. $+ E_g$ max. $= 108.6 + 36.9 = 145.5$ ft-c
(b) E_s mid. $+ E_g$ mid. $= 26.1 + 22.2 = 48.3$ ft-c
(c) E_s min. $+ E_g$ min. $= 14.3 + 13.9 = 28.2$ ft-c

Step 6 Plot the data in Step 5 on the footcandle distribution graph, figure 19.

Step 7 Determine the variables for the bilateral window.

$L = 32$ feet
$W = 32$ feet
$C = 10.625$ feet
Sill Height = 9.25 feet
$A_w = 88$ square feet

$$\frac{14 - \text{Sill Height}}{L} = .148$$

$$\frac{C}{W - 20} = .885$$

Step 8 Determine the coefficients of utilization for the bilateral window.

K_d max. = .0068 from figure 16
K_d mid. = .0117 from figure 17
K_d min. = .0108 from figure 18

Step 9 Determine the illumination at the maximum, mid, and minimum points from the bilateral window.

$$E_d = \frac{E_{id} \times A_w \times K_d \times T_g \times T_w \times M.F. \times T_d}{D}$$

(a) $$E_d \text{ max.} = \frac{572 \times 88 \times .0068 \times .8 \times .8 \times 1 \times 1}{5}$$
$$= 43.8 \text{ footcandles}$$

(b) $$E_d \text{ mid.} = \frac{572 \times 88 \times .0117 \times .8 \times .8 \times 1 \times 1}{16}$$
$$= 23.6 \text{ footcandles}$$

(c) $$E_d \text{ min.} = \frac{572 \times 88 \times .0108 \times .8 \times .8 \times 1 \times 1}{27}$$
$$= 12.9 \text{ footcandles}$$

Step 10 Plot the data in Step 9 on the footcandle distribution graph, figure 19.

Step 11 Add the curves for illumination from the main window and the bilateral window to produce the total illumination distribution curve.

The footcandle distribution curve for the bilateral test taken in the full size test house at Southern Methodist University on March 24, 1950 coincides with the total footcandle distribution curve shown in figure 19. The actual corresponding footcandle values for the full size test on the center line perpendicular to the window were 158 maximum, 73 mid-point, and 71 minimum. The predicted values are 158.4 maximum, 71.9 mid-point, and 72 minimum.

Conclusions

1. This paper presents a relatively simple and quick method for the prediction of daylighting within rooms.

2. The scope of the method will be further ex-

tended with the development of curves covering horizontal louvers and overhangs for sun exposures.

3. The authors are confident with little additional experimentation the method can be extended to cover illuminations on the other important surfaces of the room and so lead to a prediction of brightness ratios.

References

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5. Harrison, Ward, and Anderson, Earl A.: "Coefficients of Utilization," *Transactions* of the Illuminating Engineering Society, Vol. 15, p. 96 (March 1920).

DISCUSSION

R. A. BOYD:* I feel that the authors of this paper are to be congratulated on having developed a simple and direct method of predicting the daylighting of interiors. This is quite an accomplishment considering that there are so many variables to take into account. Since this material is so well presented there is not a great deal to comment on, except to cite the results of having used the method to check some of the measurements that we have made in models.

The work of the Daylighting Laboratory has included an investigation of the daylighting of school classrooms through the use of various fenestration materials in models. These models have ranged in size from $^1/_9$ to $^1/_4$ full scale. The larger models have been used outdoors with natural light while the $^1/_9$ scale model has been used with the artificial overcast sky that is part of the Laboratory.

Consequently, I have been able to use the authors' method for unilateral classrooms 30 feet by 24 feet by 12 feet and 30 feet by 30 feet by 12 feet having clear flat glass fenestrations with clear north sky and an overcast sky. The measurements included cases where 20 per cent and 65 per cent of the exterior fenestration illumination was due to ground reflected light. In all these cases the calculated illumination for the minimum point, that is five feet from the interior wall opposite the fenestration, agreed with the measured value to within ten per cent. The agreement for points close to the fenestration wall was not quite as good, but this is most likely due to differences in fenestration framing and in sky brightness distribution.

I hope that the authors will expand this method to include direct sunlight and a greater variety of brightness controls as well as to include the prediction of brightness ratios.

R. L. BIESELE, JR.:** Some four years ago, when I first suggested that a lumen method of daylighting design might be developed out of the series of daylighting studies then being conducted under my direction at Southern Methodist University for the same sponsors, I suggested also that an ultimate accuracy of plus or minus 25 per cent might be attainable with such a method. At the time, the method was first presented before this society, the method appeared to have an accuracy of this order, or better.

The present modification of the method has attained, apparently, an even greater accuracy, but the extremely close correlation reported in the present paper appeared just too good to be true. Consequently, the method as presented here has been checked against several tests reported in earlier papers of the series, with somewhat less precise correlation in some cases. It would appear, however, that the method in its present state of development can be considered accurate within plus or minus 15 per cent for the range of conditions covered by it, and it is entirely possible that the discrepancies found were the result of difficulties inherent in field tests of daylighting, and that the computation method is considerably more accurate than the field tests. At any rate, the method is far more precise than any previous method, and should prove exceedingly useful to engineers and architects in predicting the performance of a wide range of daylighting designs.

The present extensions and modifications of the lumen method are welcomed with enthusiasm. It is to be hoped that the method will be extended to include the various types of louver devices and other functional controls in the near future.

The authors have made one error in the presentation of the method which in my opinion is sufficiently serious to suggest that a further modification is in order. There is a discrepancy between the definition of the Illumination Coefficient, K, as defined on page 107, and its use in the basic equation on the same page. The definition would make of K a dimensionless ratio, which is customary usage for a factor such as this. Its use in the equation and throughout the remainder of the paper, however, would require that it have the dimension $(\text{feet})^{-1}$, since the window area, A_w, is expressed in square feet in the numerator of the equation, whereas the distance, D, in the denominator is expressed only in feet. This does not invalidate the curves or the method as presented here, but it would appear desirable at least to correct the definition of K. Better yet, it would be preferable, in my opinion, to correct the equation by using D^2 in the denominator, and recalculating and redrawing the curves for K as presented in Figs. 1 through 18, so that the usage of K in the method would be as a dimensionless factor as is customary in lighting computations.

One further point in the paper is worthy of special emphasis for the benefit of those in particular who have questioned the value of the light reflected from the ground. It will be noted in the computation on page 110 that the illumination from 300 footcandles of sky light incident on the window is 14.3 footcandles at the minimum point, whereas the illumination produced by only 200 footcandles of ground light on the window is almost as great at the same point, being 13.9 footcandles. Thus the ground light is used more effectively than the sky light in the portion of the room farthest from the window, where it is most needed. This emphasizes again the importance of differentiating between ground and sky light when making daylighting measurements, if they are to be subject to intelligent analysis and comparison with other tests.

J. W. GRIFFITH:* The example shown in this paper was used to show the procedure for predicting illumination using the modified lumen method of daylighting design. The authors did not intend to leave the impression that all predictions would be as close as this example. However, as Mr. Biesele pointed out, we have in the past two years developed new testing techniques that give considerably more accurate

*Daylighting Laboratory, University of Michigan, Ann Arbor, Mich.
**President, Toff Corp., Dallas, Texas.

*Co-author.

results in field tests and consequently give much closer correlation with our prediction technique than do some of the older daylighting surveys that would not take into account the importance of ground reflection in daylighting.

It is gratifying to find that Dr. Boyd's exterior tests agree so closely with predicted results at the more crucial minimum points within the room. The illumination near the fenestration will vary more readily from the predicted illumination than will the interior illumination when the sky brightness pattern is not the same as that used in determining the prediction technique. The curves for illumination from the sky are based on the three sky conditions and by interpolation between sky conditions; more accurate results can be obtained for skys having zenith to horizon brightness ratios between 3 to 1 and 1 to ⅓. This is only necessary when checking predicted results with measured results. For comparisons of alternate designs, which is the primary use of prediction techniques, the three standard sky conditions are usually adequate.

Mr. Biesele points out that the K factor actually is the illumination coefficient per feet when the unit of measurement is feet. The coefficient of utilization used in this paper is based on an element of area that has one unit width and a length of D units measured perpendicularly from the center of the fenestration. For simplification this unit measure has been left out of the formula for determining the illumination at various points in the room. By inclusion of this unit measure, the denominator would always be multiplied by one unit of measure and since this would not change the value of the formula but only the units of measure, the multiplication of the denominator by one has been omitted.

Mr. Biesele suggests that D^2 should be used in the denominator and that the curves for K should be redrawn to match this new formula. In the early stages of developing this technique, the formula suggested by Mr. Biesele was used but the illumination did not vary inversely with the square of the distance. This is due to the fact that the illumination is not the same for all points at the same perpendicular distance from the fenestration.

The authors would like to point out once again that in comparing measured values with predicted values of illumination, extreme care must be taken to obtain all the necessary exterior data as well as the interior illumination values.

Floodlighting an Anniversary

The occasion? The 20th Anniversary of Central Soya McMillen Feed Mills and the 75th birthday of its founder, Dale W. McMillen, celebrated at the Memorial Coliseum, Fort Wayne, Ind. Recording the event in color movie film required 500 footcandles illumination, color-corrected to 3200K. Lighting and power equipment, listed below, was installed and operated by Jack A. Frost, electrical contractors, Detroit, Mich.

Lighting and Power Equipment:

Twenty-one 10,000-watt color spots
Thirty-eight 5,000-watt color spots
Two 225-amp. brute spots
Six 170-amp. arc lights
Four 90-amp. arc lights
Six twin-arc broadsides (duarcs)
Stands, extensions, color frames, diffusing rings, gelatins, barn doors, etc.
Four 600-amp d-c generators
One 3600-amp. (single phase) transformer trailer
45,000 feet of cable — with all required plug-in bars, main line contactors, etc.

INSTALLATION AT GROVE LABORATORIES, 8800 LADUE ROAD, ST. LOUIS, MISSOURI.

Lighting an Executive Office

LIGHTING OBJECTIVE: To provide general room illumination with supplementary lighting over the desk and conference table.

GENERAL INFORMATION: The executive office shown above measures 23 feet 9 inches by 17 feet 13 inches. Ceiling height is 10 feet. Colors and reflectances are as follows:

ceiling	flat white acoustical plaster	65% RF
wall		
above cove	flat white smooth plaster	80% RF
below cove	straw	50% RF
wainscot	light oak	50% RF
carpet	mauve	16% RF
desk top	primavera wood	35% RF
drapery	red-beige	33% RF

INSTALLATION: After eighteen months use, general lighting of 36 footcandles in the center of the room and averaging 34 footcandles on the desk and table top was provided by a special Daybrite two-lamp cove around all four sides of the room. Fig. 2 shows a section of the cove construction. Lamps are 40-watt T-12 standard cool white.

Above the combination desk and conference table are recessed five Rambusch Annulites (AL-49 Alzak) each containing one 150-watt silvered bowl lamp. The Annulites in combination with the cove provide 40 footcandles at the center of the room and 50 to 92 footcandles (average 76) on the table top.

A couch on the wall opposite the window is lighted with 150-watt Certified table lamps on two end tables.

(over)

A.I.A. File No. 31-J

Lighting an Executive Office (Continued)

Brightnesses under full illumination eighteen months after installation were as follows:

ceiling	
near cove	140 ft-L
at center	11 ft-L
wall	
at wainscot	9 ft-L
brightest point (16" below cove)	14 ft-L
floor	4 ft-L
drapery	8 ft-L
cove	
bottom	8 ft-L
front face	19 ft-L
brightest point above	410 ft-L
Annulite at 45°	73 ft-L
table top	40-53 ft-L

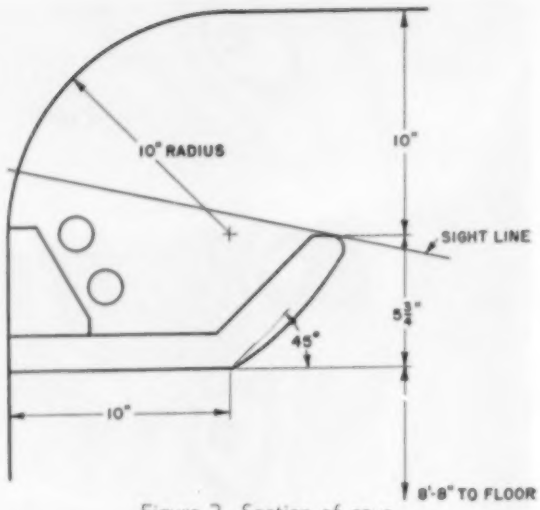

Figure 2. Section of cove.

Architects: Jamieson, Spearl, Hammond and Grolock; electrical engineer: C. H. Zurheide, all of St. Louis.

Lighting data submitted by C. H. Zurheide, Smith-Hanlon-Zurheide-Levy Inc., Consulting Engineers, St. Louis, Missouri as an illustration of good lighting practice and to aid in the design of similar installations.

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Operation of Mercury Vapor Lamps On Series Street Lighting Circuits

By M. E. KECK
W. A. OGLESBEE

THE OPERATION of mercury vapor lamps for streetlighting on a series circuit without isolating transformers has been commercially introduced to the public by at least three companies during the past year and a half. The first experimental installation in this country of public record was made in 1950 by Weston.[1]

Mercury vapor lamps have a negative resistance characteristic and so must be connected to a source of constant voltage through a suitable current limiting device. Sufficient voltage must be applied to each lamp to initiate the arc at the lowest expected ambient temperature to be encountered. Mercury lamps are designed to operate at a fixed wattage and appreciable variations from their design wattage will affect light output, life, and lumen maintenance.[2] While these lamps are instant starting, full light output is not attained until after several minutes of operation during which the lamp becomes heated. An interruption in current, while the lamp is hot, extinguishes the arc for several minutes since the voltage necessary to restrike the arc in a hot lamp is much higher than that required in a cool lamp. These characteristics must be considered in the design of any operational system and a number of circuits have been designed to permit satisfactory operation of the many types of mercury vapor lamps. The modern ballast for constant voltage supply and for operating a single lamp or pair of lamps, gives excellent results under a wide range of conditions.

At the time mercury lamps were introduced, constant-current circuits in this country were very nearly standardized at the values of 6.6 amperes and 20 amperes. Since each mercury lamp type required a different operating current it became common practice to connect them to a constant-current circuit through a two-winding current transformer with an air gap in the core to restrict the open circuit voltage at the luminaire.[2] The constant-current transformer was the current limiting device in such circuits and supplied the voltage for starting. Now that the E-H1 400-watt lamp dominates the mercury vapor lamp types used for streetlighting, constant-current systems at the exact operating current of the E-H1 lamp have been introduced thus eliminating the necessity of a current transformer.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 13-17, 1954, Atlantic City, N. J. AUTHORS: Westinghouse Electric Corp., Cleveland, Ohio.

Equipment Needed for Operation of Mercury Lamps on Series Circuits

To set up a simple series circuit for the E-H1 lamp, the following items of equipment are needed.

(1) A constant current transformer which will deliver normal operating current to the lamp. This is 3.2 amperes if the E-H1 lamp is operating vertically and 3.3 amperes if the lamp is operating horizontally.

(2) A film cutout with a breakdown voltage above the starting voltage of the lamp at the lowest expected temperature (approx. 300 rms v.) and below the flashover voltage of the parts within the outer bulb of the lamp (1500 crest volts).

(3) A luminaire to house the lamp, film cutout, and optical system with electrical clearances commensurate with the constant-current transformer open circuit voltage.

(4) A time delay device to prevent the circuit from being re-energized for approximately 8 minutes after the circuit has been de-energized thus allowing the lamps time to cool before attempting to restrike the arc.

(5) An undervoltage relay to automatically de-energize the circuit upon the occurrence of a voltage dip of sufficient severity and duration to de-ionize an E-H1 lamp.

(6) A protective relay to automatically de-energize the primary of the constant-current transformer in the event of an open in the series circuit.

The above components are available commercially and if connected as indicated in Fig. 1, will form an operational circuit. The heart of any series circuit is the constant-current transformer. Two types of constant-current transformers are in common usage; the widely used moving coil type (Fig. 2) and the static type employing either the monocyclic square circuit,[3] or the "T" circuit[4] (Fig. 3). The moving coil type regulator is well suited to the series operation of mercury lamps and the "T" circuit static type regulator can also be used. The customary monocyclic square circuit is not suitable

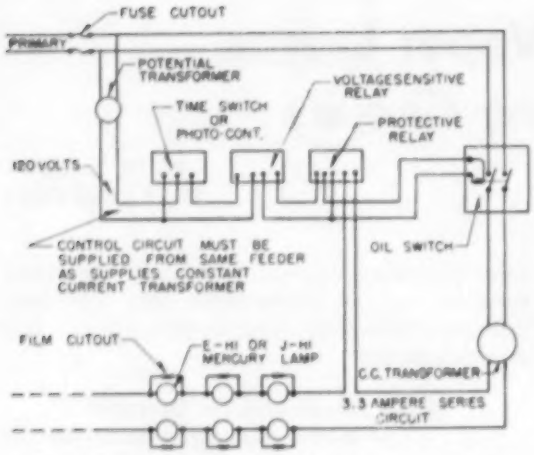

Figure 1. Connection of the component parts of a straight series system to operate E-H1 mercury lamps.

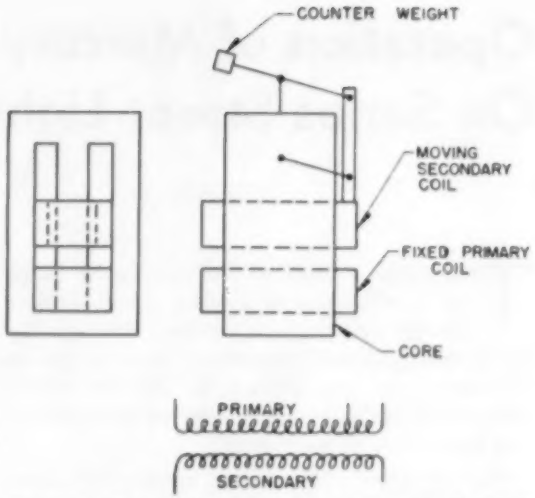

Figure 2. The well-known moving coil constant-current transformer is simple electrically and has been developed to a point where mechanically it gives many years of trouble-free operation.

for operation of mercury vapor lamps due to the peaked current wave shape produced.

An actual series streetlighting system will utilize either overhead wiring or underground cable. In either case the resistance and inductance of the circuit will be approximately the same. However, with underground cable, the distributed capacitance between the conductor and ground will be appreciably greater than when overhead wiring is used. This factor of capacitance to ground is of great significance as regards the maximum voltage appearing across individual films and lamps following a voltage dip which interrupts current through the lamps.

Operation Under Steady State Power Supply Conditions

The first important consideration for evaluating possible circuits under steady state power supply conditions is to consider the secondary crest voltage values and voltage wave shapes found upon energizing the primary of the constant-current transformer. The oscillograms of Fig. 4 indicate the open circuit voltage wave shape for both the moving coil and the static type regulator. The moving coil regulator produces a nearly perfect sine wave with no appreciable voltage peaks during starting. The static type regulator produces a transient open circuit voltage which is appreciably higher than the normal open circuit voltage and which persists for several cycles after starting. If designed with a saturable output transformer, which is the usual practice, both the transient and steady state open circuit voltages are peaked. The static type regulator because of this transient voltage may over stress the cable insulation considerably more than the moving coil type under open circuit conditions. The next factor to be considered is the current wave shape during starting and operation. The oscillograms of Fig. 5 indicate that both types of regulators provide a high value of starting current and a reasonably good current wave shape.

Since for optimum results in life, lumen output and lumen maintenance, mercury lamps should be operated at exactly the design wattage and since

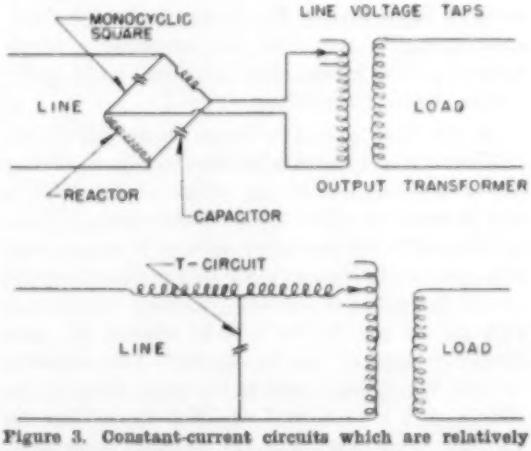

Figure 3. Constant-current circuits which are relatively complicated electrically but eliminate all moving mechanical parts are the monocyclic square circuit (upper) and the T-circuit (lower). Both circuits utilize the resonance between inductive and capacitive elements to achieve constant-current output.

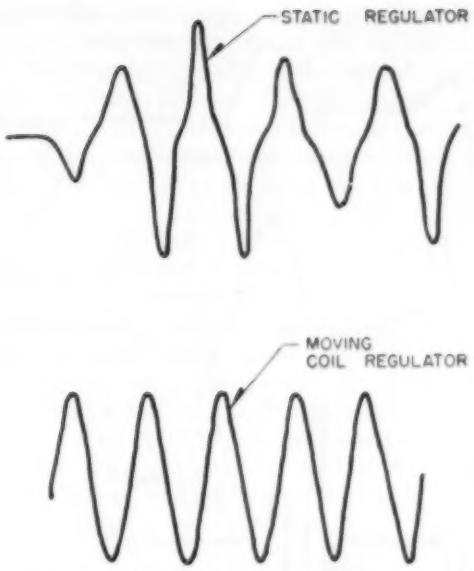

Figure 4. Open circuit voltage wave shape of static type constant-current regulator (circuit as Fig. 3) and moving coil constant-current transformer as primary is energized. Note peaked voltage wave during first few cycles of static regulator.

the provision of constant current and variable potential does not insure that the lamps will operate at constant wattage, it is desirable to determine the wattage variation which will exist if exactly the same current is supplied to a number of lamps representing the tolerance of normal manufacture. The results of such a test are shown in the table below.

Lamp Voltage	Lamp Watts at 3.3 Amperes
120 (minimum production limit)	371
130	401
135	416
140	433
150 (maximum production limit)	464

From a statistical analysis of one manufacturer's production of E-H1 lamps it has been determined that 85 per cent of the lamps produced are within the 130-140 volt range.

From the above it can be seen that a small percentage of lamps at the extreme upper end of the voltage range will fall outside the desired wattage limits of ±10 per cent.

Series circuits are normally operated with the series loop ungrounded so that a single accidental ground will not affect operation. On such a system, a single fault to ground will not interfere with operation but will change both the open circuit to ground voltage and the normal operating voltage to ground at any particular spot in the loop in accordance with the circuit constants and the location of the ground. The worst position for such a ground is adjacent to the constant-current transformer and hence for a normally ungrounded loop the insulation class of the cable and luminaire must be adequate to withstand this condition. In commercially available systems operating 25-27 lamps, the open circuit voltage is in the order of 8000 volts. It is possible to operate a series loop with a deliberate ground located at some point on that loop. If this grounded point is located at the midpoint of the load the maximum voltage to ground will be one-half that of the same system normally ungrounded but with an accidental ground located adjacent to the constant-current transformer. With a series loop normally grounded at its midpoint, a single fault to ground will render a portion of the lamps inoperative. It is questionable if the reliability of a single deliberate ground is sufficient to warrant reduction in insulation class on the equipment for a series loop.

Inasmuch as an accidental open circuit condition may stress the circuit insulation to ground to the full open circuit voltage of the constant-current transformer, equipment design must be based on the full open circuit voltage of the constant-current

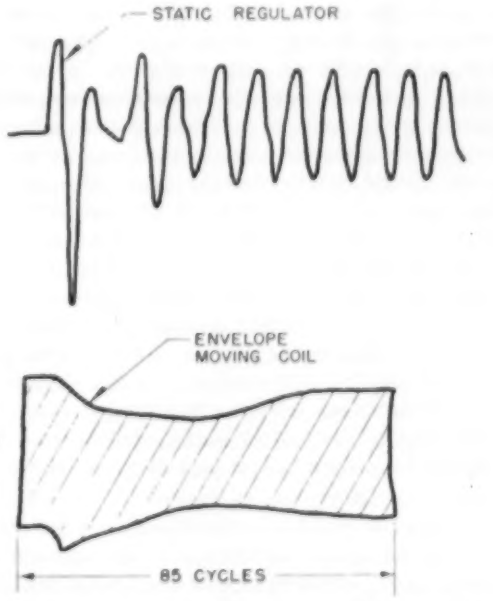

Figure 5. Current wave shape for static type constant-current regulator (circuit as Fig. 3) and moving coil constant-current transformer as circuit is energized with a load composed of E-H1 lamps. Normal current value is reached quickly with the static type regulator and more slowly with the moving coil type transformer. In both cases current values are neither excessive or unusually low during the starting period.

transformer irrespective of any circuit grounding that may be used.

Operation Under Abnormal Power Supply Conditions

In determining the reliability and suitability of any straight series system its operation under conditions of abnormal power supply must be considered. The first condition to be considered is the variation in primary voltage serving the constant-current regulator. On unregulated feeders this voltage variation may be quite large and even on well regulated feeders it will vary from 1.3 to 3.5 per cent. For a moving coil type constant-current transformer such a voltage variation will not affect the value of output current maintained but for a static type regulator of the type of Fig. 3, this will result in a current output variation about proportional to the line voltage variation. Referring to the listing above for the normal wattage variation between lamps at one current value, it is obvious that a variation in the current value will extend this normal wattage variation considerably and it is quite possible that unsatisfactory lamp life, lumen output, or lumen maintenance may result.

The second item of consideration is the behavior of the lamps, films, relays and associated oil switch on a straight series circuit as a result of extreme voltage dips of short duration. A voltage dip of approximately 50 per cent or greater (if the system utilizes a moving coil constant-current transformer which provides 300 open circuit volts per lamp) affects the lamp in the same way as a complete voltage failure for the same duration. In either case the arc current will be reduced to zero in a length of time determined by the amount of stored energy in the constant-current transformer. For a moving coil type constant-current transformer this stored energy is small and current falls to zero within one-half cycle. For a static type regulator with circuit as shown in Fig. 3, the stored energy maintains some arc current for about one and one-half cycles. Oscillograms of current and voltage for both types of regulators are shown in Fig. 6.

It must be noted that the time at which current goes to zero after the voltage is removed will depend on the stored energy of the constant-current device and the portion of the cycle at which the voltage collapses. The time before maximum voltage is again applied to the lamps depends upon the length of outage, the point in the cycle when voltage is re-established and the rate of rise of voltage due to regulator circuit characteristics. The static type regulator has a considerable amount of stored

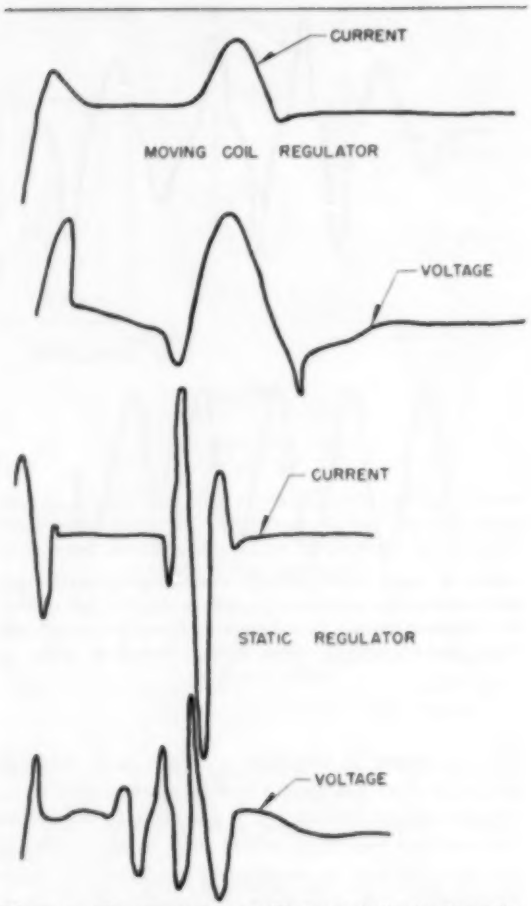

Figure 6. The upper two oscillograms indicate the relative decay and build-up of current in an E-H1 mercury lamp operated from a moving coil transformer with a short interruption of primary voltage. Current goes to zero quickly and the lamp restrikes immediately as the rate of rise of voltage is high. In the lower two oscillograms it can be seen that current decay is much slower and arc current lags behind the re-applied line voltage a full cycle.

energy and likewise the rate of rise of voltage across its secondary is slow since its stored energy must be replaced before maximum voltage can be applied to the lamp. The secondary voltage of a moving coil constant-current transformer has a very high rate of rise upon application of primary voltage. It is independent of coil position. The maximum voltage applied to a particular lamp will depend upon the crest open circuit voltage of the constant-current device, the number of lamps in the series loop and the capacitance to ground of that loop. The duration of the application of voltage following a short interruption will be the time between the re-establishment of circuit voltage and the opening of the contacts of the primary oil

switch. The crest voltage required to restrike a mercury lamp after an outage will depend upon the time from current zero to the time of reapplication of lamp voltage. This characteristic has never been fully investigated before to the knowledge of the authors and a limited investigation was made. The curve of Fig. 7 shows the crest value of voltage needed to restrike the arc after different intervals of time from current zero. This curve is based upon a limited number of lamps and therefore may not be statistically correct.

The important practical consideration is to know what will happen under voltage reductions of short duration and the frequency of their occurrence. The following analysis, based on the curve of Fig. 7, and known circuit constants is offered as an answer to these operational questions. The conditions cited have been checked on a number of laboratory circuits.

Interruptions of Less than One-Half Cycle Duration

An engineering evaluation of modern distribution systems and practices indicates that on an average distribution feeder, there is a probability of over 10 interruptions of this duration per year. These will be caused chiefly by the operation of lightning arresters. A one-half cycle interruption from Fig. 7 requires about 400 crest volts to restrike a mercury lamp. If this order of voltage is applied to each lamp in a commercial straight series system and if the relaying is so designed that it will not respond to such interruptions, no discontinuity of light will be experienced. If, however, a lower voltage per lamp is used, the lamps may not restrike on an aerial circuit with low capacitance to ground, and a light outage will result. It is the opinion of the authors that if a minimum of 300 volts (rms) per lamp is provided that interruptions of this duration will not affect continuity of operation irrespective of circuit constants.

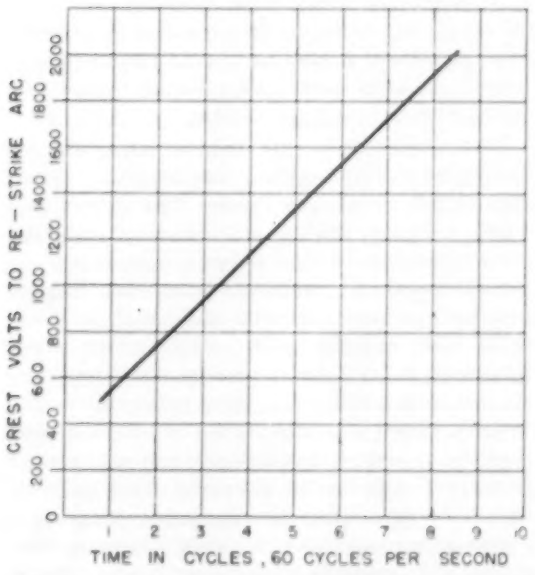

Figure 7. Crest volts needed to restrike a hot E-H1 mercury lamp is a function of time after zero in the lamp. This curve represents the results of tests on a limited number of lamps and may not be statistically correct.

Interruptions of From One-Half Cycle to One and One-Half Cycle Duration

On an average distribution feeder, very few outages of this duration will occur per year and would probably be due to faulty arrester operation. From Fig. 7 an outage of ½ cycle requires about 400 crest volts to restrike the lamp and an outage of 1½ cycles requires about 600 crest volts to restrike the lamp. On presently available commercial straight series systems the voltage available on a fully loaded constant-current transformer to operate 25 or 27 lamps is about 425 volts (crest) per lamp.

On a lightly loaded series circuit the voltage per lamp may be much higher than the 425 volts referred to above. If a fully loaded circuit having a relatively high capacitance to ground is considered, the actual voltage following an interruption, appearing across some lamps may be much higher than the 425 volts referred to above. If 300 volts (rms) per lamp is provided, outages of over ¾ cycle may cause the lamps to be extinguished on aerial circuits. It is essential therefore that the voltage sensitive relay of the system be set to operate within the range of ½ to ¾ cycle in accordance with the actual voltage per lamp available from the constant-current transformer.

In the event that the voltage sensitive relay does not operate following a ¾ to 1½ cycle interruption, the lamps may be extinguished and may fail to restrike upon the reapplication of voltage. The probability of the lamps restriking will depend upon the circuit loading and the circuit capacitance to ground. In the event the lamps do not restrike, the voltage available across any lamp will be insufficient to cause the film to pass current irrespective of the clearing time of the oil switch. This will result in operation of the open circuit protective relay which will then have to be reset before normal operation can be continued. The voltage sensitive relay, therefore, must function reliably within ½ to ¾ cycles and an 8-minute light outage will result from each voltage interruption of this length

or greater occurring on the primary distribution feeder. Assuming that a film having a crest breakdown voltage of about 600 volts is used, it can be seen that under no conditions will the voltage across the film rise sufficiently to cause the film to pass current since the short duration of current interruption will insure that the lamps will restrike before the voltage rises to 600 volts crest (Fig. 7). This breakdown voltage can be and is achieved in commercially available films. With a properly designed straight series system the few outages of this duration which might be encountered will cause a few minutes of darkness and the circuit will be returned to normal automatically.

Interruptions of From One and One-Half Cycles to Five Cycles

On an average distribution feeder several interruptions of this duration will occur per year and will likely be due to a fault on an adjacent feeder which will pull down the voltage for a length of time equivalent to the clearing time of a recloser or fuse on that adjacent feeder. With an outage of this duration, the voltage sensitive relay will operate. The operating time of a commercial oil switch is about 4-6 cycles depending on the viscosity of the oil. This means that for a current interruption of a few cycles the oil switch contacts will not open quickly enough to prevent voltage being re-established across the series circuit. From the curve of Fig. 7 it can be seen that for an outage of 5 cycles the voltage needed to restrike the arc is of the order of 1300 crest volts which is very close to the voltage required to cause an arc over in the nitrogen filled envelope and so destroy it. If it is assumed that a film with a crest breakdown voltage of about 600 volts is used and that a current interruption of 3 cycles occurs it can be seen from Fig. 7 that the lamp will no longer restrike (since 900 volts are required). The full open circuit voltage of the constant-current transformer is now applied to the films in series. If the circuit is lightly loaded or there is sufficient capacitance to ground, the voltage across some of the films will exceed their breakdown voltage and they will pass substantial current. This voltage will be present from the time the voltage is reapplied to the lamps until the voltage collapses due to the opening of the oil switch. An oscillogram of such an interruption which caused a film to pass current is shown in Fig. 8. It is possible under some conditions to reduce the maximum strain on the most heavily stressed film by midpoint grounding of the constant-current circuit. As noted below this procedure is not necessary with certain types of films.

Figure 8. Oscillogram of a relatively long voltage interruption with a static type regulator (circuit as Fig. 3). The lamp did not restrike and the film cutout passed current after the voltage build-up to a peak value. Permanent breakdown of the film occurred with no damage to the lamp.

It can therefore be expected that outages of 1½ to 5 cycles in duration can cause films to pass current under certain conditions. The circuit constants, regulator loading and uncontrollable variables between individual lamps and films will determine the specific reaction in each case. Laboratory tests indicate that some designs of films will break down and fail under certain circuit conditions with either a moving coil or static type constant current-transformer. Such failure in the field would necessitate a maintenance trip to each lumiinvolved to replace the failed film and might result in careless maintenance personnel throwing away as burned out a good mercury vapor lamp. It is not to be implied that every such outage on every circuit will cause film trouble.

An aluminum disk air-gap film has been developed which will pass 3.3 amperes for 2 to 4 cycles and then reheal so that upon the next application

of power the film is again an insulator and the lamp operates normally. Such films will not repeat such operation indefinitely but can pass 3.3 amperes for 2 to 4 cycles a number of times (6-10) before permanent breakdown occurs. Such films will break down permanently if the current duration is appreciably longer than 4 cycles. These films are commercially available and with such a film properly coordinated with other circuit components, outages of the duration of 1½ to 5 cycles should not cause maintenance problems.

Conclusions

In general it can be said that the advantages of straight series operation are balanced by a number of problems or disadvantages. These may be listed about as follows:

Advantages:

(1) Some savings in annual operating cost (5 to 12 per cent) as compared to 6.6-ampere series systems.

(2) Considerable savings in cost of initial investment (10 to 20 per cent) as compared to 6.6-ampere series systems.

Disadvantages:

(1) High voltage must be carried into the luminaire head. This introduces a safety problem and an electrical clearance problem. Luminaires should not be serviced with the circuit energized.

(2) The additional sensitive relay and its associated timing equipment, over a period of many years, may result in a maintenance problem which may be difficult to diagnose. With some systems there is a possibility of some of the films being damaged with certain lengths of line voltage dips. With such systems it may be necessary to test all lamps removed because of film failure to make certain that good lamps are not being discarded.

(3) At least a 7- to 8-minute light outage will occur with each system voltage dip lasting over ¾ cycle.

(4) It is not now possible to interchange incandescent and the various mercury lamps on 3.3-amp series circuits. New lines of equipment must be made available before this is possible.

Since the desirability of intial economic savings often overrides maintenance problems, we can expect the number of straight series systems to increase. From an operational point of view, particularly under abnormal power supply conditions, satisfactory operation will result only if all parts of the system: lamps, films, relays, and constant-current transformer have coordinated characteristics. The application engineer must ask himself these questions: How many voltage interruptions of short duration will I get on this feeder per year? Can I tolerate the possibility of additional maintenance problems? On the answers to these questions rests the future of straight series operation.

Mercury vapor streetlighting has an excellent record of service and is at present favorably received by the general public. Let us hope that we can prevent the possibility of a few overloaded or poorly coordinated straight mercury systems from ruining the opinion of the "average customer" for the reliability of all mercury street lighting.

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DISCUSSION

J. PETERSON:* I believe this paper represents a noteworthy contribution towards the clarification of the principles involved in the series mercury lighting system. However, it should not be construed as an all-inclusive treatise on all phases of this new subject because there are other significant phenomena associated with this type of operation that are worthy of the users' attention.

Considerable emphasis has been placed on behavior under abnormal power supply conditions which nobody will deny exist. However, these conditions do not necessarily have to be handled in the specific manner described in this paper. Essentially the same results are achieved with different control circuitry by other manufacturers. Undoubtedly as time develops, new abnormal conditions will be brought to light which will require further study on this particular phase of the problem.

I believe that the normal operation from day to day warrants the same emphasis. For instance, successful film cutout operation is as much of a problem during each daily start as under abnormal power supply conditions. We have observed a tendency to develop peak voltages across individual lamps just after ignition which varies considerably from lamp to lamp and probably is the most important factor in the selection of proper film cutout characteristics. We have found that the ability of copper oxide film cutouts to withstand these arc drop peaks is a very necessary function of the cutout if premature blowing of the cutout is to be avoided. Lamp people tell us that forming a cathode spot as soon as possible after ignition is desirable to minimize electrode sputtering. We feel that the arc voltage peaking is affected by this sputtering. According to our observations, the normal inrush current delivered by a moving-coil regulator over a relatively large number of cycles provides improved starting over the relatively few transient cycles of inrush current delivered by a resonant type regulator. Less sputtering occurs and the arc voltage drop peaks

*General Electric Co., Lynn, Mass.

at start are not sustained for as many cycles and the stress on the film cutout dielectric is reduced thereby.

The tendency of lamps to rectify and produce d-c current in the series circuit is probably a factor which will affect the performance of this type of circuit. Our experience in straight series sodium circuits suggests that the normal random polarity of the d-c voltage developed among the lamps should average out the net d-c voltage to a negligible value. However, it is possible that lamps near the end of life would exhibit this tendency to a degree that may prevent proper averaging. Statistical data obtained from a large number of circuits installed in the next few years ultimately will determine whether or not there are any adverse effects on the circuits from this cause.

While the authors have confined their paper to the E-1 lamp one could logically ask, "What about the A-1 lamp of the same rating?" We believe that many of the A-1 lamps will not warm up properly under constant current conditions and therefore should not be recommended for this type of operation.

The writers of this paper have pointed out several operating peculiarities of this type of system and there are others which I have indicated. However, the basic economies offered by this new system are too substantial to dismiss lightly and I am sure that the necessary co-ordination of equipment components can be achieved that will enable the user to realize these economies with a minimum of maintenance troubles.

M. E. Keck and W. A. Oglesbee:* The authors wish to thank Mr. Peterson for his comments. While we agree that this paper should not be considered as an all-inclusive treatise, we must point out that, to our knowledge, it is the only technical article thus far published. We do not feel that we have overstressed the abnormal power supply conditions. We feel that it is relatively simple to design and market a straight series system which will start the lamps and operate them under steady power supply conditions, and that the serious maintenance criticism of a poorly designed system will be the result of what we term "abnormal power supply situations."

The development of peak voltages across individual lamps during starting is a function of the individual lamp, c. c. transformer characteristics and circuit constants. This characteristic, like many others in the straight series system, demands that all components in the circuit should be carefully coordinated, each with the other. The authors do not recommend intermixing the components of one manufacturer's system with that of another manufacturer.

Mr. Peterson raises the question of a tendency for mercury lamps to rectify and produce d-c current. We, too, cannot answer positively but believe that normal random polarity will average this out to a negligible value. This is not a matter that can easily be investigated in the laboratory in a short length of time. As to the operation of the A-H1 lamp, we do not wish to comment. A brief statement might well be misinterpreted and the operation of that lamp on a straight series circuit should logically be a separate discussion.

*Authors.

GOOD vertical illumination pleased the owner, Mr. Joseph Chabot, of this Los Angeles art and frame shop, which is lighted by about 240 square feet of luminous ceiling. The ceiling is of two-foot-square polyvinyl plastic panels, eight feet above the floor. Twenty 40-watt preheat fluorescent lamps in five rows of four lamps each, are mounted on three-foot centers four feet above the ceiling. Average illumination level is 32 footcandles. Photo and data courtesy of the Department of Water and Power, City of Los Angeles.

Raceway Lighting At Vernon Downs

By R. H. GOODMAN

A compromise between the track man's dream of a mile straightaway, and the fan's wish for a tight circle, was made at Vernon Downs Raceway, Vernon, N. Y. This was a three-quarter mile track with a "chute" for mile races. Details of the lighting layout for the raceway are described in this article.

HARNESS horse men would be overwhelmingly in favor of a mile straightaway for the shape of the ideal race track. Such a track would completely eliminate the sharp turn problem and gait breaks, responsible for the majority of track accidents. The paying public rates consideration, however, and they want a tightly circled track, with the whole race within close view. For years the medium for these conflicting wishes has been the half-mile track.

At Vernon Downs Raceway, Vernon, New York, the officials came up with a new compromise in a *three-quarter* mile track, which also has a chute for mile races. This is particularly attractive from the horse men's standpoint as it gives the horses almost three-eighths of a mile of straightaway before they hit any turn. It is still compact enough to permit the spectators to follow the race closely.

Finish line is flooded to 300 footcandles from searchlights located on the grandstand roof, as the horses enter the home stretch.

Track Lighting

Floodlighting for the three-quarter mile oval track, and for the mile straightaway is from adjustable floodlights in 24-lamp clusters on each of fifteen 80-foot poles around the oval, on 200-foot spacing. They are lamped with 1500-watt PS-52 general service lamps operated ten per cent above rated voltage for a 35 per cent increase in light output. Along the chute and grandstand eight poles, each with 32-lamp banks, illuminate this area. The finish line is highlighted by four 24-inch 3000-watt searchlights located on the grandstand roof, and six 1500-watt floodlights on a pole on the rail side of the finish line. These ten units are turned on at half power after the start of a race, and as the horses enter the home stretch are beamed down at full power to spotlight the finish.

All floodlights were adjusted in accordance with an aiming chart developed in advance of the in-

AUTHOR: Application Engineer, Illumination Dept., Crouse-Hinds Co., Syracuse, N. Y.

Day view of the grandstand shows the four 24-inch searchlights mounted 50 feet above the track on grandstand roof and six 1500-watt floodlights on a 20-foot pole, to floodlight finish line.

stallation. The direction of each floodlight was calculated on paper, and this information transferred to angular settings on the chart.

Lighting values obtained are: Track, 20 footcandles. Finish line, approximately 300 footcandles.

A sub-station erected on the premises provides 13,300 volt service for this installation, including the parking and paddock areas not here described. The track sub-station consisted of three 500-kva transformers feeding three-phase, three-wire, 13,300 volts to a secondary sub-station located adjacent to the grandstand. There the outgoing voltage is three-phase, four-wire, 2400/4160 volt. In this secondary sub-station are manually operated oil switches controlling the transformer circuits located along the track, grandstand, parking and stable areas. No two adjacent poles are on the same circuit so that if a cable failure occurs, only a minimum section of the track is darkened.

White Light for Television

NBC's television studio 6-B at Radio City, New York will be equipped this month with a new development for studio lighting — an inside silica coated 1000-watt lamp which eliminates the need for a spun-glass diffusing "scrim" in producing a diffused white light. The new source is here being installed by a studio electrician in a "scoop" fixture used for general lighting. Overhead fixtures equipped with the lamp are operated without the former covering of spun glass that in diffusing the light also reduced the light output by approximately one-third, and presented maintenance and color problems. *Westinghouse photo.*

The Diamond Jubilee of 1954 and It's Effect on Streetlighting of Tomorrow

By W. EARLE HAWKINS
W. S. TILL
D. W. ROWTEN

WAYS and means of lighting our roadways to reduce the number and severity of traffic accidents has attracted the attention of everyone from the President of the United States to the parents of every child. Certainly any subject that may contribute to our knowledge or foretell future trends in lighting techniques justifies our consideration.

The I.E.S. has always been very much interested in streetlighting and many of us have had some part in the development of the American Standard Practice for Street and Highway Lighting. This Practice has been developed over a period of years from considered observations, calculated techniques and miscellaneous incidents, each contributing its part.

New ideas and techniques applicable to roadway lighting are often borrowed from many sources. The acceptance of new ideas, new products or new methods may be accelerated by some extraordinary event or by testimonials that these new ideas are indeed satisfactory.

We in the lighting field have profited by such exploration. Sometimes it may have been difficult to determine the chronological order. Did the event stimulate an advancement of the art or did the new product or technique suggest the occasion? The introduction of new lighting tools and techniques has been so closely associated with World Fairs, Expositions, and Jubilees that we reference one to the other.

The stimulus to our industry credited to these occasions can be verified by the records of the past:

(a) The use of alternating current for lighting was introduced at the World's Columbian Exposition (1893) in Chicago. We may credit the exposition as being responsible for the first mass use of decorative electric lighting, including external floodlighting of buildings and the embryonic beginning of multiple incandescent street lighting.

(b) The Panama Pacific International Exposition (1915) at San Francisco was noted for the decorative treatment of street lighting poles. Fairly high wattage incandescent lamps were used behind yellowish tinted globes. Market Street was referred to as the "path of gold." Perhaps this helped pave the way for the acceptance of sodium lighting, which later became familiar on the West coast.

(c) There was a gradual transformation in street lighting practices from carbon arcs and Welsbach gas mantles to low wattage multiple incandescent lamps probably reaching its greatest acceptance about the time of the Sesqui-Centennial (Liberty Bell Celebration, 1926 in Philadelphia.

(d) The application of refractors and prisms in conjunction with fairly large single ornamental lanterns was emphasized during the celebration of "Light's Golden Jubilee" (1929). Series incandescent street lighting was becoming well established at this time also.

(e) The 400-watt A-H1 mercury lamp was introduced for industrial lighting in this country at the "Century of Progress" celebration (1933) at Chicago. Certainly the effect of the Fair at Chicago stimulated and made possible the relighting of State Street which was the first ornamental street lighting application of incandescent lamps rated at over one kw.

(f) The World's Fairs at San Francisco and New York (1939-1940) introduced fluorescent lighting in this country for commercial and industrial applications. It was also used for spectacular decorative effects. Improved mercury lighting was used extensively for special floodlighting effects and for fountain displays. Treasure Island at San Francisco featured the use of colored fluorescent displays and the San Francisco Bay Bridge is remembered for its sodium lighting.

We cannot dispute that these great and momentous occasions of the past have had their influence on street lighting development and practices. It is only natural then, that remembering the past, we anticipate that something new would be un-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 13-17, 1954, Atlantic City, New Jersey. AUTHORS: W. Earle Hawkins, Senior Engineer, Atlantic City Electric Co.; W. S. Till and D. W. Rowten, Westinghouse Electric Corp.

veiled at this Diamond Jubilee Celebration. As a background for this announcement, it is fitting that we review the foresight and planning that preceded this celebration.

We in the lighting industry are indeed fortunate when we have as associates, individuals of the stature that comprise the management of the Atlantic City Electric Company of New Jersey. We are doubly fortunate when we have city officials and engineers with enthusiastic interest in improving street lighting.

About five years ago, those in charge at City Hall and the management of the Atlantic City Electric Company decided to improve the street lighting in Atlantic City. They had in mind a plan that would increase property values, encourage civic pride, reduce accidents, contain all the other intangible benefits of good street lighting and at the same time be able to provide this service at a bargain to the city and a profitable revenue to the stockholders of their company. We are sure, of course, that many other cities have adopted similar plans, but to discuss their activities would be beyond the scope of this paper.

The Engineering Department of the Atlantic City Electric Company was commissioned to determine the lighting requirements for the streets of Atlantic City and prepare engineering plans accordingly. These engineers solicited the combined assistance of the outstanding street lighting engineers of the country and together they evolved a long range modernization plan that, though not yet completed, is climaxed in this Diamond Jubilee Celebration.

A street plan of Atlantic City, Fig. 1, was studied as to traffic flow, business concentration, pedestrian traffic and potential growth so that an orderly sequence of improvements could be made in line with requirements.

The streets selected for improvement in the first plan are shown on Fig. 2. These streets comprised residential, traffic and commercial areas and were placed on the first schedule for improvement on the basis of their potential realization of the original aims. The lighting plans for each of these streets were prepared in strict accordance with the provisions of the American Standard Practice for Street and Highway Lighting, sponsored by the Illuminating Engineering Society.

Fig. 3 shows the streets that have been improved up to and including the first half of 1954.

The first street to be relighted under the improvement plan was Absecon Boulevard. A part of the transition is illustrated by Fig. 4. The old lighting consisting of 4000-lumen filament lamps

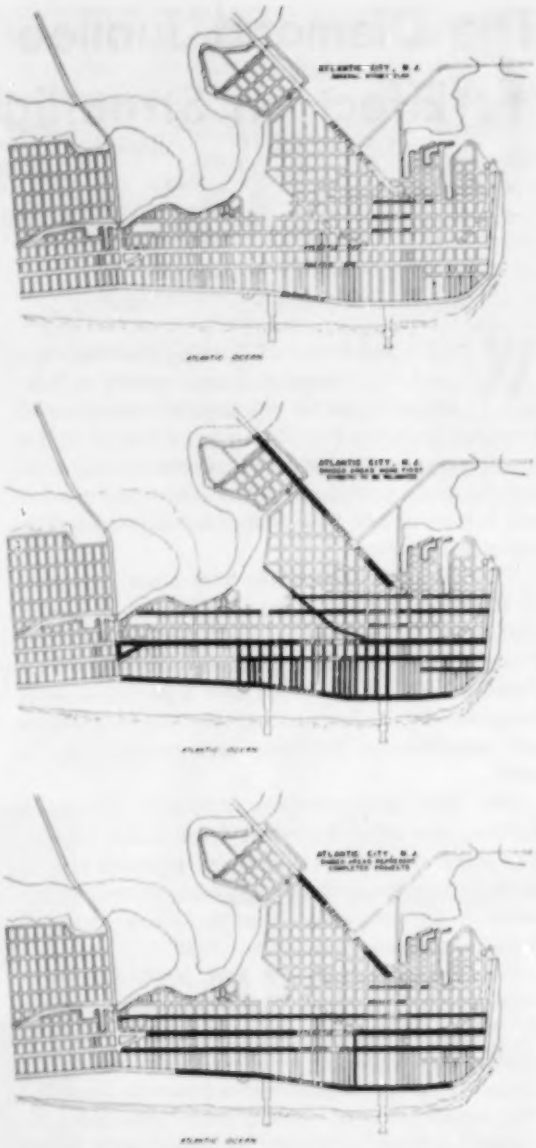

Figure 1. (Top) Overall street plan of Atlantic City.

Figure 2. (Center) Streets in the first modernization plan.

Figure 3. (Bottom) Streets where relighting was completed by the first half of 1954.

on relatively long spacings was inadequate and well below the minimums recommended by the ASA Practice for roadways carrying the volume of vehicular traffic common to the Boulevard.

In keeping with the best considered practices, those making the selection decided to use the mercury light source for this very important street. The luminaire used the 400-watt E-H1 mercury

Figure 4. The first street to be modernized.

lamp operating in a horizontal position. The new system provided about five times as much light as the old system and soon became the standard in the Atlantic City area.

The second improvement was made on Pacific Avenue, Fig. 5. On this street, a modern pendent luminaire using the 10,000-lumen filament lamp provided the illumination value recommended for such a business street. The Type IV light distribution from this luminaire is accomplished by the use of a refractor type globe in addition to the reflector.

Still a different luminaire and lamp were used to relight Atlantic Avenue, Fig. 6. This luminaire with a 15,000-lumen filament lamp provides a Type IV light distribution from an enclosing globe aided by a bi-flector.

Neither of the three lighting systems used on the first installations have monopolized the modernization program. There have been and will be many extensions of each of the systems depending upon the specific classification of and requirements of the roadway then under consideration.

The orderly sequence of the overall lighting modernization plan was interrupted by the necessity of doing something outstanding for the Boardwalk in anticipation of the Diamond Jubilee Celebration, and particularly the 100th Anniversary of the founding of the city, which would attract many conventions to Atlantic City in 1954.

Artists, industrial designers, architects, and illuminating engineers from far and near were invited to present proposals and designs calculated to give the Boardwalk a new look with a practical lighting installation. Scores of designs were presented as typified by Fig. 7.

Figure 5. The second street to be modernized.

Figure 6. The third street to be modernized.

Specific Requirements

Following the laborious reviews of many proposals, a committee composed of the management of the Atlantic City Electric Company, city officials and representatives of the Boardwalk Association decided on eight basic requirements:

1. Average *maintained* illumination of 2.0 footcandles minimum — which at once implied a source of at least 30,000 lumens initial output;
2. Yet with wider spacing of standards than at present — to lessen "picket fence" effect;
3. And with in-built provisions for future increase to 3-plus footcandles without major changes to the system;
4. Illumination of color suited to the application — a wide pedestrian promenade with extraneous (color-correcting) light available, for the most part, only from the side opposite the luminaires;
5. Rugged, non-corrosive equipment — for minimum maintenance in spite of continuous exposure to salt atmosphere;
6. Equipment of low windage — to withstand storms of gale, or even hurricane force;
7. A finished system epitomizing 75 years of progress in the lighting art;
8. And at comparable first cost.

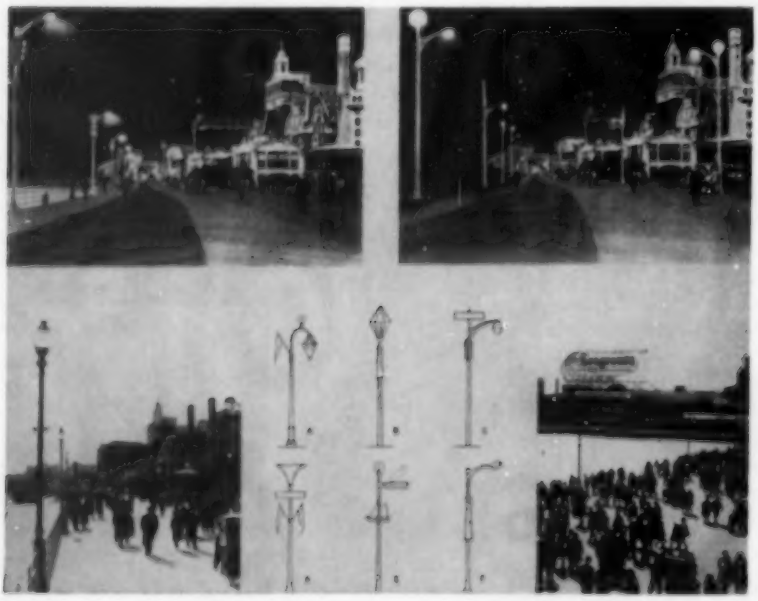

Figure 7. Original proposed design for the Boardwalk.

Choice of a Lighting Medium

The years of planning afforded continuous opportunity for evaluation of all available light sources and luminaires against these conditions. A choice was offered between the conventional filament source, the yellow sodium light, the standard mercury source, the tubular fluorescent and a new fluorescent mercury unit.

In order to avoid a repetition of the picket fence effect of standards located too close together, it was obvious that a relatively large package of light would be required to obtain the illumination levels specified in the project requirements. The physical layout of the Boardwalk suggested several special problems in design of the lighting.

1. A one-side arrangement (ocean side) was mandatory since standards support railing, and interference with valuable building fronts could not be tolerated.
2. Block lengths are, in general, close to 400 feet and because of the necessity for street signs, it was required that a luminaire be located at each street end.
3. Thus, distance between centerlines of intersecting streets was divided as equally as possible, the only deviations being those required by the various abutting piers, pavilions and special structures for the comfort of visitors.

With the project requirements in mind, a luminaire evaluation chart was helpful in showing at a glance the points rating of the equipment considered.

New Developments in Tandem

Rarely, indeed, does the street lighting engineer have an opportunity to design the equipment specifically for an installation. He is usually engaged in fitting existing models to his requirements. Yet here is an all-out instance of the former procedure.

The establishment of a desired intensity (point 1) from fewer luminaires (point 2) suggested a tandem development of luminaire and light source to fit the order. The Boardwalk and its heavy pedestrian traffic in a commercial environment suggested a wide light distribution pattern and a lamp of 30,000- to 35,000-lumen rating.

A new fluorescent mercury lamp, 700-watt in size and providing 33,000 lumens was developed and designated as a B-H18. The development of a multiple 113/120/127 volt high reactance ballast took place at the same time as did that of the new luminaire.

The new luminaire, Fig. 8, combines modern design, rugged construction to provide today's highest illumination values. The luminaire conforms to the electrical and mechanical specification of NEMA and EEI as well as the light distribution patterns of ASA-IES — Fig. 9.

Like the smaller luminaire which accommodates the 250-watt H-5 (11,000-lumen) and 400-watt H-1 (15,000-, 19,000- and 20,000-lumen clear, fluorescent and clear mercury, respectively) sources, the new luminaire accommodates not only the H-18 lamps but the 50,000 (B-H15 fluorescent mercury) and 53,000 (A-H15 clear mercury) lumen 1000-watt sizes as well. Thus, the main Boardwalk lighting level can be increased 40 per cent — to 3 footcandles (point 3) — by a simple change to the B-H15 lamp and ballast at any time.

Hinging glassware, cast housing and non-corrosive construction of the luminaires make for minimum maintenance and maximum salt resistance — (point 5).

A special hollow spun concrete standard was developed for the Boardwalk that requires a minimum of maintenance in spite of the severe service encountered so close to the ocean. Air-entrained cement seals the salt out while the steel re-enforcing wires are hot dip galvanized as final assurance against rust from within. Shafts are of the new "pre-stressed" construction for maximum density, flexibility and strength. The concrete brackets not only harmonize well, but are likewise maintenance-

LUMINAIRE EVALUATION CHART.

(Fixture with Lamp) Luminaire	Project Requirements								Final Rating
	(1) "20 fc Maintained"	(2) "Wider Spacing"	(3) "Expansion"	(4) "Suitable Color"	(5) "Maintenance"	(6) "Windage"	(7) "Progress"	(8) "Comparable Cost"	
Incandescent	No*	No*	No	Yes	Yes	Yes	No	No*	37½%
Sodium Vapor	No*	No*	No	No	Yes†	Yes†	No	No*	25%
Fluorescent	No*	No*	No	Yes	No*	No	Yes	No	25%
Mercury Vapor	Yes	Yes	Yes	No	Yes	Yes	No	Yes	75%
Fluorescent Mercury	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%

*Either lamp or fixture not available, feasible, or economical.

†If closed type.

NOTE: In ordinary business and traffic street lighting, higher lamp efficiency, higher utilization and more favorable cost of "straight" mercury vapor would normally outweigh requirements #4 and #7.

Figure 8. The lighting unit selected for the Boardwalk.

free. The only exposed metal parts of the standard assemblies are the three-quarter-inch thick cast-steel spider base, the bronze inserts (for railing and street sign attachment) and the heavy wall hot-dip galvanized two-inch slip-fitter. A festoon convenience outlet at a 17-foot height provides for decorative lighting.

Color of the Light Source

By prior test in Atlantic City and by direct investigation of similar applications elsewhere, the fluorescent mercury source was selected because it provides light of adequate spectral balance (point 4) far superior to that of either sodium or plain mercury vapor. Its distinctive color is preferred by many over the incandescent lamp. Through popular usage, the incandescent light has come to be accepted as "standard" yet is known to decentuate violet and blues and over accentuates objects or orange or red hue. The addition to the mercury lamp of a phosphor, magnesium fluorogermanate, which fluoresces bright red under the abundant ultraviolet of the mercury arc, results in fluorescent mercury, with color correction.

Competent observers have termed the color rendition on the Boardwalk excellent. This is not surprising in view of the extensive and wholly acceptable three-year experience with fluorescent mercury lamps in industry — their primary application. Thousands of these lamps are now used in plants employing large numbers of female workers whose complexions respond favorably to fluorescent mercury lighting.

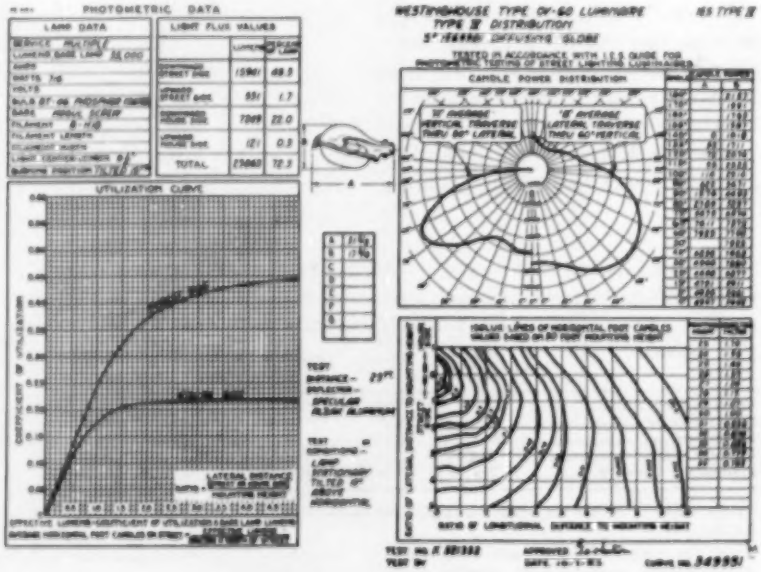

Figure 9. Photometric performance for the new luminaire.

The installation of the Boardwalk lighting system was made easy by the efficient planning and coordination executed by the Engineering Department of the Atlantic City Electric Company. The sequence of installation may be followed by reference to Fig. 10.

A. With handhole cover removed, the #10 AWG stranded 600-volt RH-RW wires are connected to the porcelain terminal block. Leads of 40-foot length were pre-cut in quantity. Pressure type connectors speed this one-wiring operation, the fixture being factory wired, socket to terminal block with silicone rubber-glass insulated leads. Separate packing of glassware-ring assembly eliminates hazard and time loss in handling this item until the standard is erected and the lamp is installed. High temperature insulation is provided by 10-inch lengths of #10 NEMA Class H-A1 "Fiberglass" sleeving slipped over bare copper adjacent to the terminal block.

B. With the leads previously fed through the bracket and shaft, the fixture is being tightened in the approximate position on the slip fitter. The fitter is two inches, since the luminaire weighs 47 pounds. Note that the attachment of the bracket to the shaft is by means of a full length slip-fit over the two-inch pipe extension cast in the shaft.

C. The Boardwalk foundations consist of concrete piles on 20-foot centers. On these, rest the bents (transverse supports) of re-enforced concrete. All standard locations fall between the bents. Front joists between the bents are double 4 x 14 in the 60-foot section, and 3 x 12 in the 40-foot section. The latter required addition of a 4 x 14 x 37 scab, attached by 8⅞ x 14 bolts, for extra support as here illustrated. Extra stiffening was obtained at all locations by adding 4 x 14 bridging from the front to the second and second to the third joists.

The base plate is one-piece cast steel, three-quarter-inch thick and hot-dip galvanized. It is recessed 1½ inch into the joists, mounted by four horizontal and two vertical through bolts. The plate incorporates an 8 x 8 opening, a built-in splice chamber and two captive studs (leaded into hubs) for the mounting positions which occur over the joists.

D. With a rope sling attached at the balance point, one man easily guides the base of a 1,050-pound standard assembly over the base plate. Then the winch raises is to vertical position and lowers it to the plate. When the cast steel spider of the standard is bolted to the mounting plate, using the shims for plumbing, erection is complete.

E. Final alignment of the standard. Note the hot-dip galvanized sheet steel splicing the chamber cover, held in place by bronze studs; also the railing attachments.

F. The ballast is close-coupled to the base plate through a one-inch side opening. Service cables enter through a two-inch rear opening (joists also two inches through-drilled). Thus, all wiring is concealed. A regular aerial mounting bracket, lagged to joist, provides rigid ballast mounting under the overhang of the 2 x 4 decking. Note the redecking completed around the base of the standard.

Figure 10. Illustrations of installation techniques.

Wiring and Control

Since the major portion of this 123-unit system lies within the underground network area, electrical supply is 3-phase, 4-wire, 120/208 volts. Feed for the five units in each block (and for the relay controlling the adjoining block, since this is a "cascaded" system) is taken from the closest secondary supply point, either vault or junction box. This consists of three-conductor SE cable strung along the inside edge of the front joint. There are no cable breaks (splices) between the standard splicing chambers.

Spiral wrap of the cable is connected to the

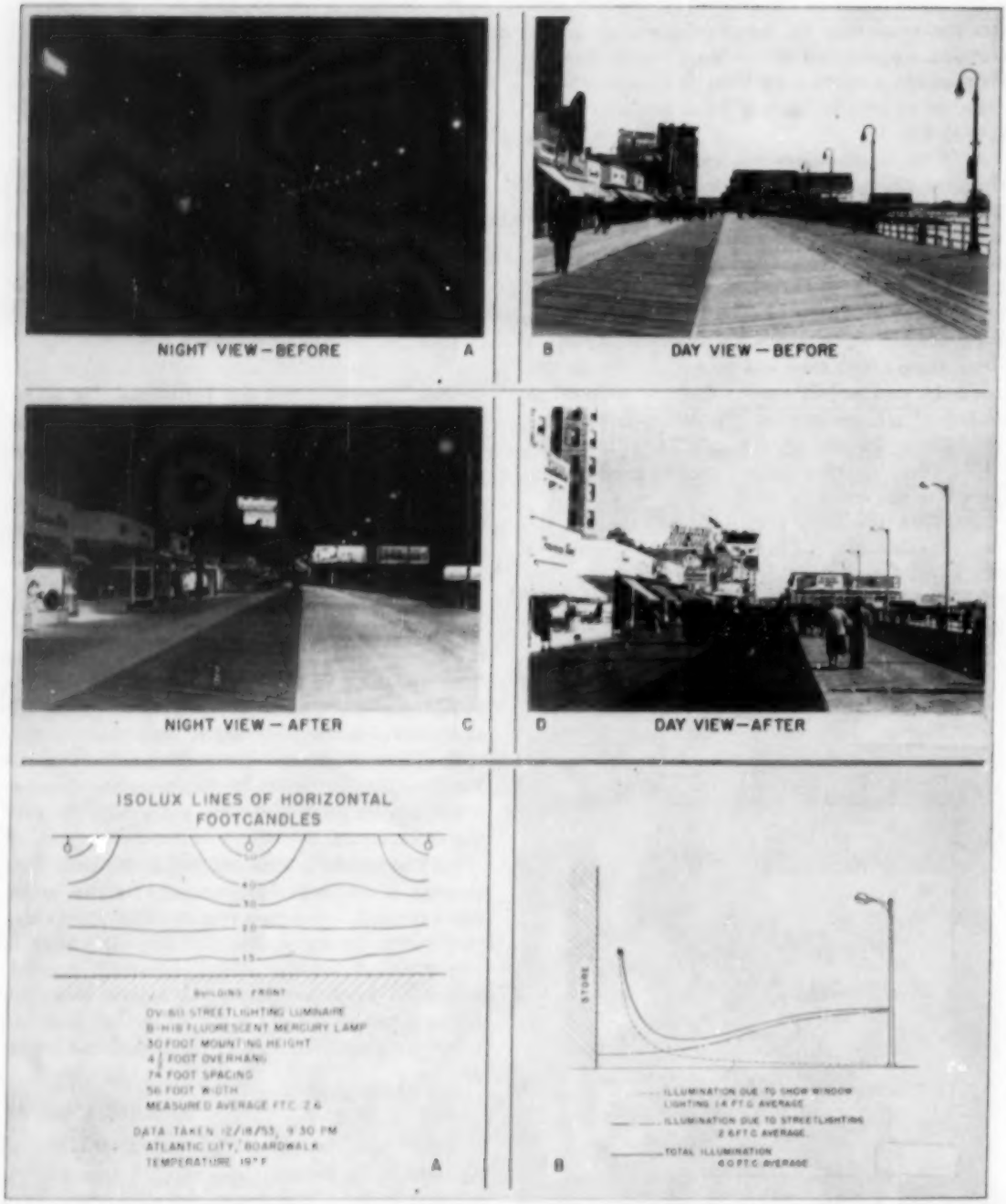

Figure 11. (Above) Before and after relighting illustrations. **Figure 12. (Below) Measured lighting results.**

system ground, all standards and ballasts being grounded to it. One conductor is used as the phase wire, the other as a neutral, this being grounded through a normally closed relay (energized during daylight to keep the lights off). Relays are 60-ampere, sized for the open circuit condition.

Decorative lighting requirements are frequent and varied, so a separate three-conductor SE cable supplies the festoon convenience outlet in each standard. This circuit includes a similar relay, actuated by the street lighting relay which is de-energized by fuse removal when decorative circuits are not in use.

Master control of the entire system is a photocell

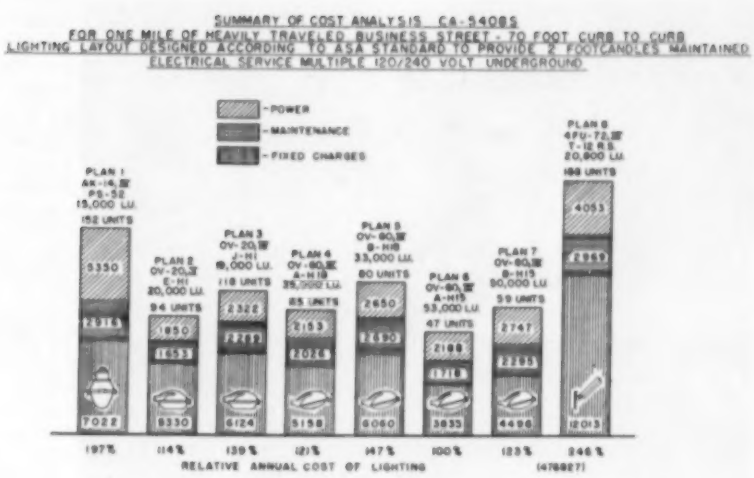

Figure 13. A projected trend into the future.

located on the roof of the five-story Atlantic City Electric Company main office building on Pacific Avenue, one block away. This switches a 120-volt pilot wire to the first relay.

The Dedication

On January 6, 1954, in Atlantic City, New Jersey, an official dedication took place for the new lighting installation on the Atlantic City Boardwalk. This installation of fluorescent mercury luminaires is the first of its kind anywhere in the world utilizing such a large mercury light source in a practical application.

The Boardwalk has indeed, a "new look," not only in name, but in fact, for all items comprising this installation are "firsts" — never before used in lighting a public way. Specifically the list includes a new size light source — in a new street lighting luminaire — on a new design standard — and operated from a new ballast. The new look can best be illustrated by a side by side comparison of the old and the new.

Fig. 11 — the "before" night picture "A" compared with the "after" "C" portrays the improved night-time appearance. Because of identical exposure and printing, these views afford accurate direct comparison of the old and new systems. A comparison between the before "B" and after "D" daylight views shows a transformation of improved appearance worthy of the Boardwalk.

The measured results in terms of illumination values measured according to the suggestion of the I.E.S. Committee on Testing Procedures reveal that the actual results were in excess of the project requirements, Fig. 12. The actual readings taken were converted to isolux lines of horizontal footcandles as shown in Chart A. Chart B shows the measured illumination across the Boardwalk with only the new lights burning, with the show window lights only, and with the combination of all lights contributing to the general lighting.

The supreme test of any lighting installation is measured by the degree of public acceptance. The tourist or casual visitor to Atlantic City accepts the new lighting as the natural environment of the Jubilee spirit. They have the assurance of being well protected without the feeling of being spotlighted.

The merchants along the Boardwalk are keenly aware of the "New Look" partly because they had a part in its planning but particularly because the results are up to their expectations.

A Forecast

Those who have had a part in this Diamond Jubilee Celebration will look with interest for the permanent influence of the occasion.

Like the before-mentioned World Fairs and Expositions at which were introduced new light sources and techniques, The Diamond Jubilee of 1954 will quite likely be associated with the introduction of the large size fluorescent mercury luminaire to roadway lighting.

Light sources for the foreseeable future will include the familiar filament lamp, further experiments with tubular fluorescent lamps, but the promise of greatest acceleration seems to be with the mercury source, either plain or fluorescent.

This trend toward the larger light source for roadway lighting appears to be justified by typical cost of lighting studies similar to the summary illustrated in Fig. 13.

Figure 14. A beacon and a diamond to remember.

Luminaire manufacturers can and will provide lighting equipment that will adequately shield and direct the light flux from any of the popular light source to permit a quality lighting job in line with the ASA Practice as suggested by the Street and Highway Lighting Committee of the Illuminating Engineering Society.

In years to come as we reflect on our experiences from this year, we will remember the theme of the Absecon Beacon, Fig. 14, and "The String of Diamonds in the Sky," the Boardwalk lighting of 1954.

DISCUSSION

HAROLD E. MASON:* I want to congratulate the able gentlemen who prepared this paper especially for the many firsts which they have accomplished with the new boardwalk lighting.

In the mercury vapor lighting field, we have been limited mostly to the use of the 400-watt lamp for our commercial and traffic streets; but now with the introduction of this new luminaire which can use a 1000-watt or the new 700-watt lamp, we have a new tool for our largest and most important commercial and traffic streets. I am looking forward with considerable anticipation to the solution of some of our street lighting problems in Philadelphia with these large type units. Like the horsepower in the American automobile, is there any end to this increase in size?

I have had the opportunity to make field measurements on this boardwalk installation, and also on a new 1000-watt, 53,000-lumen, straight mercury vapor installation, in this same type of luminaire, located in a parking lot at Norristown, Pa., just outside Philadelphia. I understand that this is the first 1000-watt mercury vapor installation in a street lighting type luminaire. In this parking lot, single units are used around the outside edge and provide a maximum of 5.0 footcandles under the light. Under twin units in the middle of the lot, the maximum is 8.5 footcandles under each light. Therefore with this Type IV luminaire, the lighting engineer must in some cases decide which is more important, minimum ratios or twin unit economy. Possibly the twin unit minimum ratios can be improved by shielding.

I am interested in the tilt of this new luminaire and will watch to see if this becomes a trend in future Type IV and Type III units for wide streets. Also, will the tilt be in the luminaire or in the pole such as the davit type pole? Can the authors tell us if such tilts meet Civil Defense requirements?

In this boardwalk installation, the massive design of the concrete bracket, to go with the larger luminaire, seems pleasing to me, and I hope that the metal pole companies will have something similar to offer us.

As the 700-watt mercury vapor lamp is new, can the authors tell us how many are in use on the boardwalk, their average age to date, and how many have been replaced to date? Were all the heat problems solved with the precautions taken? What is the lamp replacement policy? Will long-life lamps be replaced before they burn out?

R. M. SWETLAND:* To the authors, our appreciation for an interesting and informative paper; to the Atlantic City Electric Co., a commendation for a progressive and forward-

*Street Lighting Engineer, Philadelphia, Pa.

*Outdoor Lighting Department, General Electric Co., Lynn, Mass.

looking approach to the street lighting modernization program in Atlantic City in general — and to the Boardwalk in particular; and to the Westinghouse Electric Corp., credit for developing the new lamp, ballast and luminaire combination employed in the Boardwalk installation.

This "new look" along the Boardwalk at night is timely and fitting, in aiding the commemoration of Light's Diamond Jubilee.

Space limitations suggest only a few general observations relative to that part of the paper dealing with "Street Lighting of Tomorrow — a Forecast."

(1) Most street lighting engineers agree that "maximum visibility per dollar of investment" is the prime objective in all street lighting modernization programs. This emphasis does not seem to appear in the authors' discussion.

(2) With reference to light sources in future street lighting practice, one sees the statement, "the promise of greatest acceleration seems to be with the mercury source — either plain or fluorescent." This may well be true in terms of *quantity;* or total generated light. But in terms of *quality* of illumination, or *maximum* visibility and comfort-in-seeing, the conviction is growing that the tubular fluorescent lamp is already setting the standard of excellence.

(3) Paralleling the growing use of the fluorescent lamp in street lighting — and, to a considerable degree, due to this growth — the "American Standard Practice" must soon contain a more accurate and inclusive basis of street lighting evaluation, other than the present "average footcandle" method of appraisal.

(4) Holding the above opinions, therefore, specific comments are offered on two assertions in the paper, namely:

> (a) In the "Luminaire Evaluation Chart," page 129, the "25 per cent rating" of the fluorescent luminaire seems unjustifiably low — even based on the selected 8 "project requirements."
>
> (b) In Fig. 13, page 133, "Cost Analysis Summary," the "246 per cent relation assigned to the fluorescent system is fully 15 per cent high, in terms of the established performance of one well-known, 4-lamp luminaire — and, of course, still higher on a judged (by many) basis of comparable visibility.

Finally this central section of the Boardwalk is extremely well lighted.

KIRK M. REID:* I offer three comments on this interesting paper.

(1) The authors undoubtedly are aware that the night photographs showing the Boardwalk and the Atlantic City streets "before relighting" are not realistic. Here is another case where our technical literature on street lighting is weakened by "before and after" photographs which show exaggerated contrasts. True, it is difficult to take photographs of lighted streets which are realistic, particularly where the lighting is not very good. However, both British[1] and American[2,3] authors have shown how it can be done, and at least within the Society's Committee on Street and Highway Lighting there appears to be agreement that the results are worth the effort.

(2) The authors state that the Luminaire Evaluation Chart was very helpful in choosing the equipment for the Boardwalk relighting. They tell me they are *not* proposing this chart as a general guide in choosing equipment for "street lighting of tomorrow" — as is implied by the title of the paper. They might wish to make clear the limited purpose of the Chart, perhaps by expanding its heading.

But would not some sort of Luminaire Evaluation Chart, or Lighting System Evaluation Chart, if it could be worked out in comprehensive form, be useful to street lighting purchasers? The Society's Committee on Street and Highway Lighting might think it worthwhile to develop such a chart, embodying the collective experience and judgment of the Committee to appraise its possibilities.

The Luminaire Evaluation Chart in the paper might well serve as a starting point, although in its present form it has two major shortcomings. First, it does not include such factors as light distribution and globe brightness which directly affect the primary objective of a luminaire or lighting system. That objective might be expressed as "maximum visibility per dollar of total street lighting cost, with comfort." Second, it employs a numerical rating scale which places equal weight on each of the secondary considerations covered by the Chart. The resulting "scores" are startling. Fluorescent lighting, although it has been demonstrated here and abroad to be a superior lighting system for promenade areas, as well as for business streets and main traffic arteries, comes in with a score of only 25 per cent. Sodium, which surely no one would consider acceptable for such areas, likewise gets 25 per cent. And filament lighting, in spite of its long record of effectiveness in lighting all classes of streets, scores only 37.5 per cent. These scores attest to the incompleteness of the tabulation, and to the pitfalls in using numerical values to summarize such a series of unequal factors. Very likely it is because of these shortcomings that the authors are not proposing it for any general use.

(3) The authors conclude by stating that "luminaire manufacturers can and will provide lighting equipment that will adequately shield and direct the light flux from any of the popular light sources to permit a quality lighting job." This statement recognizes that luminaire designers have not yet succeeded in providing street lighting of really good quality with the popular filament and mercury sources. "Quality lighting" in this case might be defined broadly as a distribution of illumination and roadway brightness providing good visibilty, together with a minimum of discomfort and veiling glare.

This goal of quality street lighting is not new. Luminaire designers in this country and abroad have been seeking it for many years. They have produced luminaires giving high utilization efficiency, and effective distribution of illumination and roadway brightness. But why has so little been accomplished in suppressing discomfort and veiling glare in luminaires with the popular filament and mercury sources? Perhaps a brief review of the factors affecting veiling glare and discomfort glare will aid in understanding this problem.

Veiling glare, interference with seeing, is determined chiefly by (1) the angle between the line of sight and the luminaires, and (2) the footcandles on the eye from the luminaires. The *brightness* of the luminaires is of lesser importance, although a larger luminous area of reduced brightness is in the direction of reduced veiling glare. A major reduction in veiling glare requires a major reduction in spacing-mounting height ratio, because then the luminaire designer can lower the angle of maximum candlepower without sacrificing desirable distribution of illumination and pavement brightness. It is encouraging that we are making progress in this direction. Two decades ago a spacing-mounting height ratio of about 8:1 was accepted

*Lamp Division, General Electric Co., Cleveland, Ohio.

good practice. Now it is about 4:1 on arterial streets, and perhaps 6:1 on local-traffic residential streets. To the extent that this trend continues, luminaire designers can reduce veiling glare.

Discomfort glare is determined chiefly by (1) the angle between the line of sight and the luminaires, and (2) the luminaire brightness. The footcandles on the eye are of lesser importance. Very close spacings, with cutoff types of luminaires, are one answer. But for present accepted spacings, an increase in luminous area, with attendant lower brightness is the only course open to the luminaire designer. However, for comfortable street lighting the need is not to reduce luminaire brightness by some moderate percentage. The brightness must be reduced greatly. This means that the size must be increased greatly — beyond any size to which designers of luminaires for filament and mercury lamps have thus far been willing to go.

Now comes fluorescent street lighting, with well-engineered light distribution. Luminaire designs *must* be big to house the lamps. Being big, the brightness is low and we now have, for the first time, a huge stride toward comfortable street lighting — quality street lighting.

But fluorescent has no corner on comfort and quality. I share the authors' conviction that quality lighting can be achieved in luminaires employing filament and mercury sources. They propose to do it by "adequately shielding and directing the light." This course, judging by experience in this country and abroad, succeeds only where spacings are very short — not more than 2½ to 3 times the mounting height. Where spacings are 4 to 5 times the mounting height, or more, shielding sacrifices effective light distribution. Instead, luminaire designers may well ponder the distinguishing feature — very large size — which enables fluorescent luminaires to give a relatively high degree of comfort along with effective light distribution at representative spacings. Luminaires for filament and mercury sources might likewise be made large.

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EARLE HAWKINS, W. S. TILL and D. W. ROWTEN:* The authors wish to thank Messrs. Mason, Swetland and Reid for their comments.

Mr. Mason's appraisal of the lighting results on the Boardwalk compliments Mr. Hawkins and his associates in the Atlantic City Electric Company for their design and installation skill. The authors are pleased that Mr. Mason's observations are in agreement with their conclusions.

We are pleased to answer Mr. Mason's specific questions as follows:

The upward component of light from the Boardwalk luminaire is well within the limits as suggested by the Civilian Defense Committee.

The initial installation on the Boardwalk included a total of 88 B-H18, 700-watt color improved mercury lamps. Their average burning hours up to November 1st was 4,712 hours. Of the original lamps only three have been replaced.

During the first season of operation it has been the policy to replace lamps upon failure or when the lamp appears dim or off-color. Group replacement has been considered, and may be adopted, after sufficient operating experience has been gained to permit a thorough evaluation of maintenance costs.

The comments of Mr. Reid and Mr. Swetland are similar in intent, so perhaps the answers to their criticisms can be grouped together.

It is the authors' opinion that the paper fulfilled the purpose and scope intended. We undertook to review the circumstances that contributed to the selection of a new lighting system that highlighted the Diamond Jubilee Celebration and commemorated the 100th anniversary of Atlantic City.

Both Mr. Swetland and Mr. Reid state that we have not given proper consideration to light distribution, globe brightness, quality, etc. in evaluating the several lighting systems under consideration. In answer to this we remind the discussors that we have only recorded the processes followed by the Atlantic City Electric Company and the Boardwalk Association. In recording a proceeding of this kind, we, the authors, do not presume to criticize the decisions of others; rather we have attempted to report accurately the proceedings.

The authors do not believe that the participants in this discussion are wise in selecting this medium as a vehicle for discussing the principles of luminaire design or the techniques of application.

We are sure that everyone interested in streetlighting realizes the urgency and need for more adequate criteria for evaluating quality and relative visibility of a given lighting system. However, until such a new evaluator is developed and generally accepted we may well refer to our Standard Practice as a guide to acceptable practice.

Mr. Swetland and Mr. Reid also question our conclusions and particularly the bar diagram summarizing a typical cost of light analysis. The cost analysis reflects actual published prices for lighting equipment. The installation costs are from the records of reliable contractors, utilities and municipalities. Certainly it indicates a trend that is reflected in current installation practices. A typical cost analysis is based on stated assumptions and, therefore, may not be adaptable to a different set of conditions.

The authors have recognized the existence and place for all existing light sources. They believe that either light source, when used in equipment designed to meet the objectives of the Street and Highway Lighting Committee's suggestion for light distributions, will result in maximum visibility as evaluated by current standards of measurement.

Mr. Reid's point of the before and after night photographs, as reproduced, not being realistic is well taken. These photographs were taken by a member of the Subcommittee on Street Lighting Photography in accordance with the best accepted techniques. The original photograph truly depicted the before and after appearance of the Boardwalk. The change in appearance was due to the reproduction process employed in reproducing the picture for publication purposes.

*Authors.

Cavity Efficiency For Translucent Ceilings

By R. T. JEAVONS
R. H. HORNER
R. D. BURNHAM

THE AMOUNT of light successful in emanating from a translucent ceiling, as with any luminaire, is in direct proportion to the illumination developed in the enclosure. In this article, cavity efficiency will indicate the ratio of lumens transmitted through the light diffuser to lamp lumens. This term is synonymous with fixture efficiency.

The translucent ceiling can be visualized as a large troffer which extends from wall to wall. The efficiency with which it emits light is not constant as it is with a troffer. Cavity efficiency will vary depending on room size, cavity depth, cavity reflectance, and physical obstructions, to state a few.

In some cases, practice has been to assume that the cavity is shallow and the length and width go to infinity.[1] In this case, cavity efficiency is expressed by equation 6 in the appendix. This is generally optimistic to a greater or lesser degree, depending upon the physical configuration. In a relatively small room, $K_r = .9$, the error would be in the order of 20 per cent. Equation 5 gives more accurate results. It assumes that half of the light goes up to the structural ceiling and half goes down to the diffuser and that the walls of the cavity absorb a negligible amount of light. Equation 2 in the appendix, as developed by Moon and Spencer[2] expresses the cavity efficiency (logance) in terms of the optical properties of the diffuser, the cavity reflectance and configuration, as well as lamp position in the cavity.[3]

The theoretical equations are handy tools for the design and application of translucent ceilings, but it is desirable to validate theoretical information by measurement for the sake of practical application.

Of particular interest was the investigation of relatively deep cavities and the advisability of using reflectors above the lamps. This phase could not be predicted from present theory. It was believed that this information could best be determined by constructing a scale model of a cavity designed in such a manner that the cavity shape could be altered.

*AUTHORS: The F. W. Wakefield Brass Co., Vermilion, Ohio.

Test Model

The test cavity was a rectangular tube, 4 ft by 5 ft and 8 ft 9 inches long, with the interior painted white with a reflectance of 85 per cent. One 4 ft by 5 ft end of the box was closed with an acrylic, corrugated light diffuser; a movable rectangular panel was used to close the other end of the tube. This was painted white to represent the structural ceiling and could be placed at any position up to 8 ft 9 inches away from the light diffusers. The distance between the panel and the light diffuser was varied to give a cavity shape factor (K_r') from a .338 to 3.0. Since the main interest was in cavity efficiency with relatively deep cavities, this seemed adequate.

Twenty-one inch T-5, 13-watt lamps were selected because they closely resembled the size of 48-inch T-12 lamps in $^5/_{12}$ scale. The electrical channel and corrugation wave length was designed at $^5/_{12}$ scale. Sixteen lamps were used with a ladder type electrical channel (lamps perpendicular to channel) to form a battery of lamps, two lamps end to end, and rows on 7-inch centers. This represented lamps on 17-inch centers in full scale. The lamp grid could be placed in any position in the cavity in a parallel plane with the light diffuser.

A barrier layer cell was mounted several feet from the acrylic diffuser on the outside of the box. It was so shielded that it acted as a wide angle brightness meter, integrating the brightness over the luminous panel. The current output of this cell provided a relative cavity efficiency. This system was calibrated by setting the cavity depth and lamps in such a manner that the panel brightness was fairly uniform. A number of brightness readings were taken over the panel area with a Luckiesh-Taylor brightness meter and averaged to give the average brightness. This value times the luminous area ratioed to the lumen output of the test

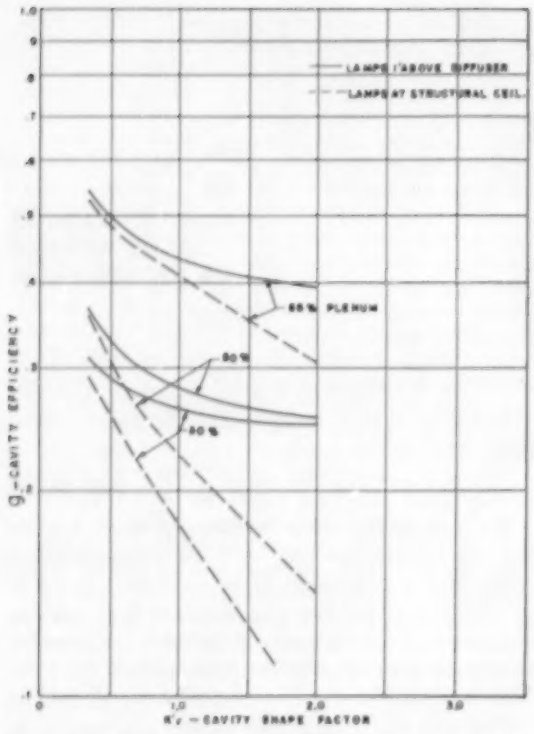

Figure 1. Test data for two lamp height positions and three cavity reflectances.

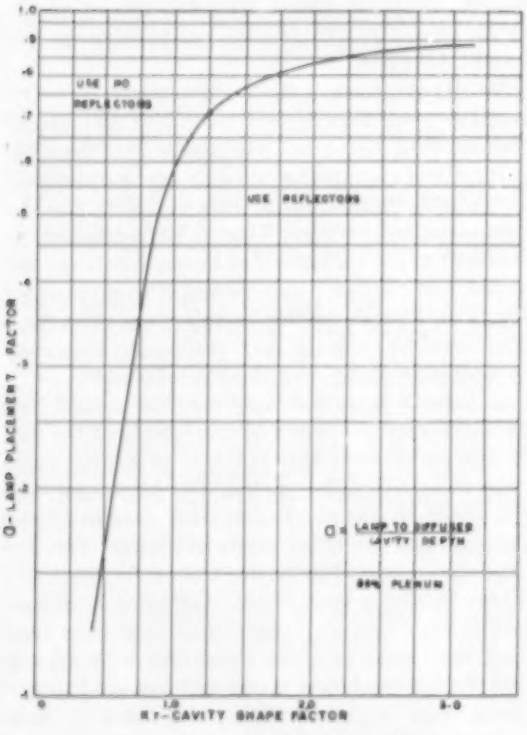
USE NO REFLECTORS
USE REFLECTORS
Q = LAMP TO DIFFUSER CAVITY DEPTH
80% PLENUM
Q - LAMP PLACEMENT FACTOR
K_r' - CAVITY SHAPE FACTOR

Figure 2. Break-even curve for reflectors.

lamps gave an absolute cavity efficiency. This was correlated with the cell reading and a linear response assumed.

The seasoned lamps were allowed to preheat for 30 to 45 minutes before each test. Another ten minutes period was allowed to establish heat equilibrium after changing lamp position or cavity depth.

The light diffuser was so suspended that it was not within 15 feet of any surface other than the cell and its supporting bar.

Although this arrangement did not allow precision measurement, its accuracy was believed to be within plus or minus 8 per cent which was considered satisfactory for the purpose.

Test Results

No attempt will be made to present all of the test data. Only the more important aspects will be presented in graphical form.

It is generally agreed that lamps may be mounted near the structural ceiling when the cavity depth does not exceed two or three feet. When the cavity becomes deeper, the question is raised as to the best location of lamps in the cavity. It is realized that for greatest overall efficiency, the lamps should be kept close to the diffuser. The limiting factor is appearance.

Fig. 1 shows the test data for two lamp height positions and three cavity reflectances. The solid line assumes an arbitrary lamp placement at one foot above the diffuser. The dotted line shows the response with the lamps at the structural ceiling.

It is not possible to go to a cavity shaped factor (K_r') of less than .338 due to the limited size of the model. Even though further data were taken at greater proportional depths the curves are terminated at $K_r' = 2$ since the practical significance above this region seems dubious.

Test data so far represent the use of fluorescent lamps without reflectors. This is, in general, the most efficient system provided the cavity is relatively shallow and the cavity walls are white. As the cavity becomes deeper, a break-even point is reached, beyond which it is more efficient to use reflectors above the lamps. The reflectors used in the test were simple steel reflectors, finished on both sides with synthetic white enamel with .86 reflection factor. The intensity distribution approaches a spherical shape similar to that of many industrial totally direct luminaires. One of these reflectors was used above each lamp following the pre-determined $^{5}/_{12}$ scale.

The break-even curve is shown in Fig. 2. The use of reflectors depends on lamp position, cavity

shape and cavity reflectance. Cavity reflectance has been held constant at 85 per cent for this curve; "a" indicates lamp position. With a given set of physical conditions, a point on this graph is indicated. If the point lies to the left of the curve, the most efficient system would be without the use of reflectors. If the point lies to the right of the curve, the converse is true. There is no direct correlation between this curve and actual cavity efficiency.

The cavity shape factor for most installations of translucent ceilings is less than .5. Reflectors are usually not required for these conditions, provided the cavity is white and the area is relatively free of obstructions.

Theoretical and Test Data

The theoretical equation (Equation 2) is plotted in Fig. 3 for the acrylic diffuser with a transmission of 62 per cent and a reflectance of 31 per cent to duplicate the material used in the test model. There seems to be a significant difference between theory and test. But under the original supposition under which these tests were conducted and the limiting accuracy of the test model, this deviation does not seem unlikely.

While it was not possible, due to the number of variables investigated, to test several types of light diffusers, it is relatively easy to compare them using the theoretical data. A vinyl plastic diffuser and an acrylic plastic diffuser are compared in Fig. 4. Typical optical properties are taken although these will vary depending on the thickness and composition of the particular sample.

The curves diverge slightly as K_r' increases. The difference in transmission between the two is more than 20 per cent. However, the difference in cavity efficiency through the range normally encountered is in the order of 10 per cent.

Conclusions

The coefficient of utilization for translucent ceilings is composed of two entities, the product of the utilization factor and cavity efficiency. One is as important as the other and should be determined with the same accuracy.

By assuming the cavity to be infinite in size for a relatively large shallow cavity sufficiently accurate results may be obtained. In practice it is not uncommon that a translucent ceiling be used to lower the ceiling height of older buildings. This sometimes leads to cavity depths substantially greater than anticipated. This being the case, more extensive data, such as described, must be used in order to maintain comparable accuracy in illumination and brightness predictions.

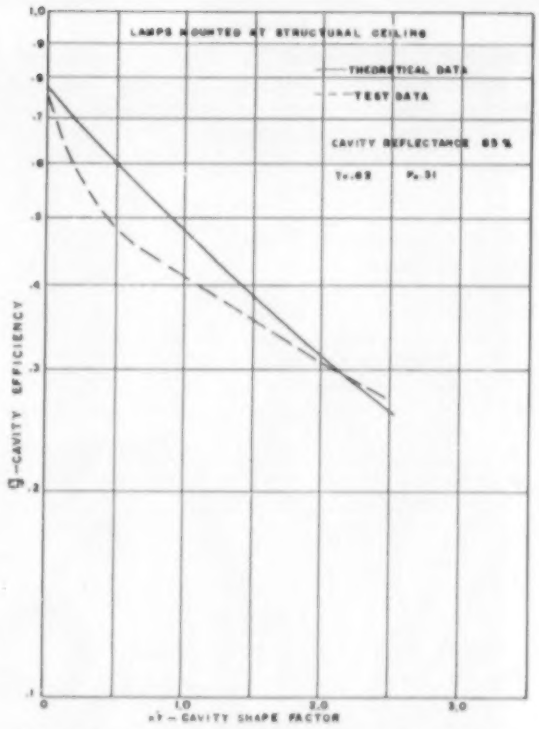

Figure 3. Equation (2) plotted for acrylic diffuser.

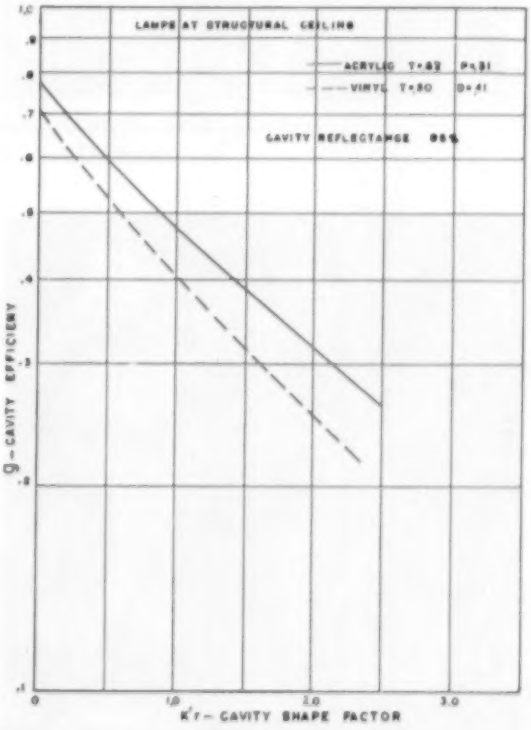

Figure 4. Comparison of vinyl plastic diffuser with acrylic plastic diffuser.

Appendix

Interflectance Theory[2]

Equations have been developed which enable the designer to calculate cavity efficiency. These equations assume that all surfaces have perfect diffusion.

Terms

l = room length
w = room width
h = floor to light diffuser height
h_p = cavity depth
K_r' = cavity shape factor
C_c = ceiling reflectance of cavity
C_w = wall reflectance of cavity
C_d = light diffuser reflectance
F_l = total lamp lumens
F_w = incident lamp lumens to the wall of plenum without interflections
F_c = incident lamp lumens to the structural ceiling
F_d = incident lamp lumens to the light diffuser
T = Transmission of light diffuser
g = cavity efficiency

$$K_r' = \frac{h_p}{2}\left[\frac{l+w}{l \times w}\right] \quad \text{Equation (1)}$$

Then the general equation for cavity efficiency is:

Equation (2)

$$g = \frac{T}{\Delta}\left[\frac{C_w}{4K_r'}\left(\frac{F_w}{F_l}\right)(1-e^{-2K_r'})\,[1+C_c e^{-2K_r'}] + \frac{C_c e^{-K_r'}}{2}\left(\frac{F_c}{F_l}\right)[2e^{-K_r'}+C_w(1-e^{-K_r'})^2] + B\left(\frac{F_d}{F_l}\right)\right]$$

Where

Equation (3)

$$\Delta = [1-C_w(1-e^{-K_r'})]\,[1-C_d C_c e^{-4K_r'}] - \frac{C_w e^{-K_r'}}{2}(1-e^{-2K_r'})\,[C_d + C_c(1+2C_d e^{-2K_r'})]$$

Equation (4)

$$B = 1 - \frac{C_w}{2}(1-e^{-K_r'})\,[2 + C_c e^{-K_r'}(1+e^{-K_r'})]$$

If the cavity walls reflect negligible light this equation takes the form.

Equation (5)

$$g = \frac{T}{1-C_d C_c e^{-4K_r'}}\left[C_c e^{-2K_r'}\left(\frac{F_c}{F_l}\right) + \left(\frac{F_d}{F_l}\right)\right]$$

If $K_r \longrightarrow 0$

Equation (6)

$$g = \frac{T(1+C_c)}{2(1-C_d C_c)}$$

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PART-TIME RESTRICTION is the designation for this "blank-out" traffic sign being tested in Portland, Ore., in the city's peak-hour traffic restriction program.

The interior-illuminated sign has two acrylic plastic panels. The first, a clear plastic, is installed across the front of the sign, behind which is a heavy-duty translucent white vinyl-impregnated shade on which one regulatory message is imprinted. The shade is fastened to a spring roller and is held in lowered position by motor tension. When the time-clock-controlled motor releases this tension, the shade is pulled up to reveal the part-time restriction message imprinted on the inner translucent acrylic panel. The interior sign message is not visible through the translucent shade, yet enough light passes through to give this message the same readability. The sign is lighted by two or more U-shaped cold cathode lamps, rated at 15,000 hours each.

Photo and data from the Elwood Wiles Co., Portland, Ore.

INSTALLATION IN METER STANDARDIZATION LABORATORY,
DALLAS POWER AND LIGHT COMPANY.

Lighting a Meter Standardization Laboratory

LIGHTING OBJECTIVE: To provide a high level of illumination with minimum reflected brightness in the covers of meters being tested and the test instruments.

GENERAL INFORMATION: Watt-hour meters are tested and standardized in this laboratory. Two such meters are shown on the work bench in front of the test panel. These meters sometimes have dome shaped glass covers and reflect the brightness of all light sources on the ceiling. The three large meters on the work bench behind the test panels are galvanometers with 15 inch wide glass faces in a horizontal plane and with a mirror across the meter scale beneath the indicator needle. In order to read the instrument accurately one must align the very thin needle with its reflection in the mirror. At this position the glass face and the mirror reflect the image of any light source on the ceiling. Therefore a luminous ceiling of uniform low brightness capable of furnishing a high level of illumination seemed desirable.

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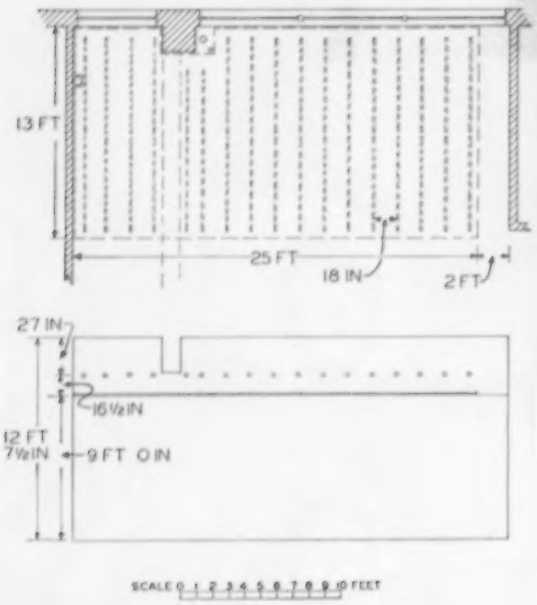

Figure 2. (left) Plan view and elevation; Figure 3. (above) Close-up of instrument panel.

Fig. 2 shows the dimensions of the laboratory. Colors, reflectances, and brightnesses are as follows:

Area	Color	Reflectance (%)	Brightness (ft-L)
Painted walls	Cream	77	28
Brick walls	Cream	77	28
Ceiling at 45°	(Plexiglas)	—	135
Floor	Reddish brown	19	7
Bench top	Blue green	22	10
Panel background	Black	3	1.3
Panel nameplate	(Brushed aluminum)	—	23

INSTALLATION: Average horizontal illumination is 110 footcandles; vertical 50 footcandles. Lighting is provided by 32 72-inch T-12 and 2 48-inch T-12 standard cool white preheat fluorescent lamps spaced on 18 inch centers and 15 inches above a corrugated plastic diffuser. Brightnesses are indicated above.

Fig. 3 is a close-up photograph of the meter panel taken at an angle showing the reflected ceiling brightness. However, even at this angle the meters are clearly readable.

Lighting data submitted by Ruth Patterson, Dallas Power and Light Company, Dallas, Texas as an effective solution to a meter laboratory lighting problem and to aid in the design of similar installations.

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Series XX 3-55

A New Low-Cost Dimmer For Hot Cathode Fluorescent Lamps

By ARIEL DAVIS
ROBERT E. STEPHENSON
L. DALE HARRIS

This paper describes a newly developed method for brightness control of hot cathode fluorescent lamps.

BRIGHTNESS of hot cathode fluorescent lamps can be controlled by means of variations in line voltage. If this is done in a manner similar to that used for incandescent lamps, however, the results are unsatisfactory unless some auxiliary technique is applied. Instability results when line voltage is reduced, with the lamp being extinguished when about 50 per cent of normal brightness is reached. It is difficult, if not impossible, to restart the lamp with reduced line voltage because the starting voltage is also reduced.

The Lamp Ballast

Whenever gas discharge lamps are used, it is necessary to use lamp ballasts with them. These ballasts have three functions when used with hot cathode fluorescent lamps. These functions are:

(1) To limit the lamp current,
(2) To supply the filament current for heating the cathode,
(3) To increase the line voltage to a value high enough to initiate conduction through the lamp.

The current limiting function is necessary because of the effect of the negative resistance characteristic of the fluorescent lamp. As far as the lamp itself is concerned the voltage drop across it, when it is conducting, becomes lower as the current increases. The ballast choke coil is therefore necessary in series with the lamp to prevent the current from becoming excessive. The other functions of the ballast require no additional explanation. The necessity for these functions is self-evident.

Dimming by Voltage Reduction

If voltage reduction in the conventional manner is employed to dim a fluorescent lamp, the voltage across the series ballast coil, S_1 (See Fig. 1) decreases, producing an increase in lamp voltage and a decrease in lamp current. This accomplishes the desired dimming effect but as the line voltage is decreased, unstable operation results and the lamp extinguishes. The system of brightness control described in the following material overcomes the unstable operation feature of dimming by reduction of applied voltage, and thereby allows the system to be used. The system is simple and relatively inexpensive.

Fig. 1 is a circuit diagram showing the arrangement of the various components. The circuit and lead arrangement have been designed in this ballast to allow the connection of the control autotransformer, T, as shown. By means of this arrangement, it is possible to vary the voltage applied to the lamp and the series ballast coil, S_1, while keeping the electrodes hot and avoiding unstable operation.

It is desirable when using fluorescent lamps to keep the electrodes at a temperature sufficiently high for satisfactory thermal emission of electrons.

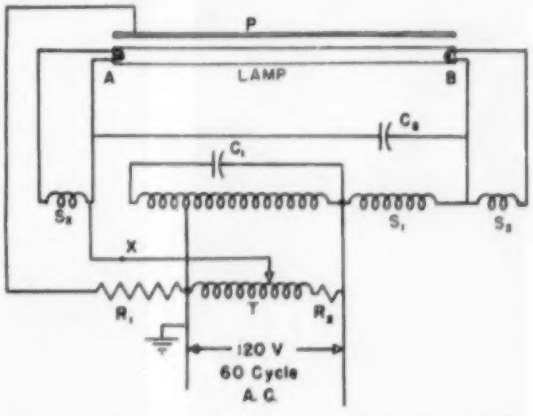

Figure 1. Circuit diagram showing arrangement of the various components.

AUTHORS: Ariel Davis, President, Ariel Davis Manufacturing Co., Salt Lake City; R. E. Stephenson, Associate Professor and L. Dale Harris, Professor, Department of Electrical Engineering, University of Utah, Salt Lake City, Utah.

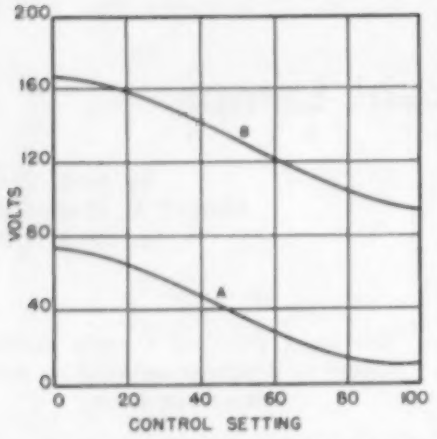

Figure 2. Voltage between metal starting plate and lamp electrodes varies with control setting.

If the temperature of these emitting electrodes is allowed to decrease below the proper emitting temperature the resulting ionic bombardment will remove material from the electrode surface and decrease the life of the lamp. Fig. 1 shows that the current for heating the filaments is obtained from two secondary windings, S_2, on the ballast transformer. The voltage applied to the primary of the ballast transformer, being always equal to line voltage, does not change with variations in the auto-transformer setting. The filament voltage and current are thus kept constant, and the filaments are kept at the proper operating temperature regardless of control auto-transformer setting.

Changes in the setting of the control auto-transformer do, however, cause changes in the voltage appearing across the lamp and its series ballast coil. These changes in voltage result in changes in lamp brightness as described earlier. Stable operation is achieved by the effect of the grounded metal starting plate, *P*, placed near the lamp and parallel with it. It is electrically connected as shown in the circuit diagram. The luminaire itself could be used for this purpose instead of a separate metal starting plate. For proper operation, this metal starting plate or luminaire must be electrically connected to the input line which supplies power to the unit. To insure the safety of personnel coming in contact with the starting plate or luminaire, this connection is always made on the grounded side of the input line.

The voltage between the metal starting plate and the lamp electrodes varies with control setting as shown in Fig. 2. These potential differences cause sufficient ionization to initiate conduction. By this means the lamp will conduct and restart instantly at all control auto-transformer settings.

The brightness control obtained by this method is smooth and continuous, not stepwise as in some controllers. Variations in brightness covering a range of over 100 to 1 can be obtained easily.

Oscillograms

The wave shapes of lamp current and voltage in this application are typical for 60-cycle fluorescent lamp operation. The oscillograms shown in Fig. 3 below show the shapes of these waves. The current wave shown was measured at point *x* in Fig. 1. Current measured at this point includes not only the lamp current but also the current through the shunt capacitor, C_2. This capacitor is connected in parallel with the lamp to suppress radio interfer-

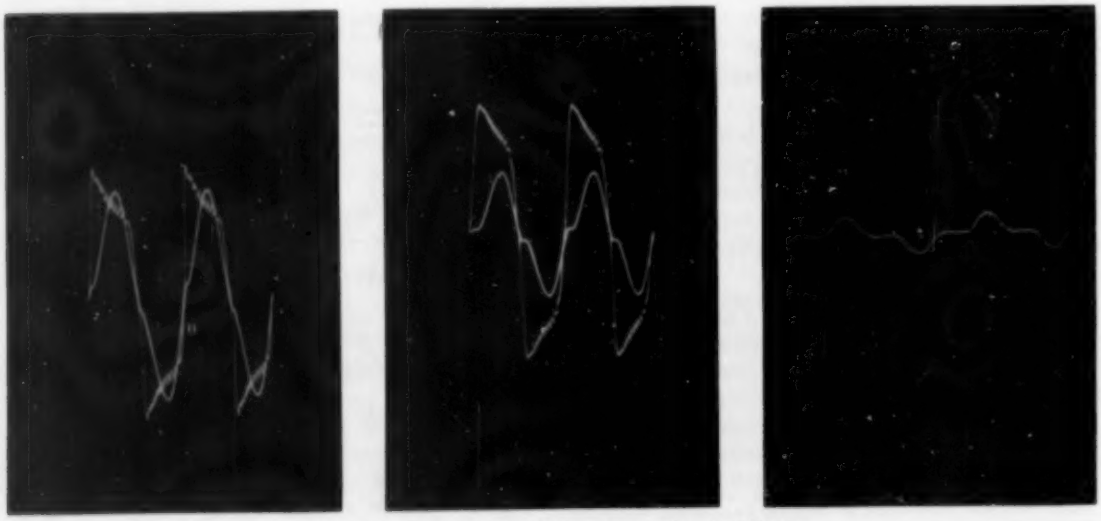

Figure 3. Wave shapes of lamp current and voltage.

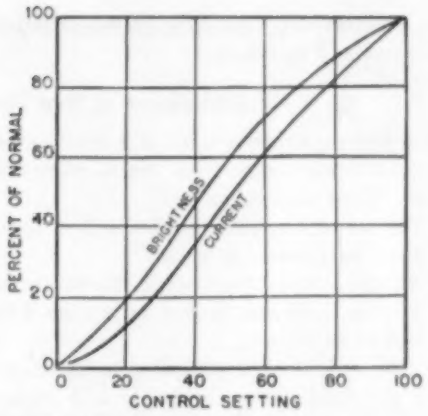

Figure 4. Variation of lamp brightness and lamp current versus controller setting.

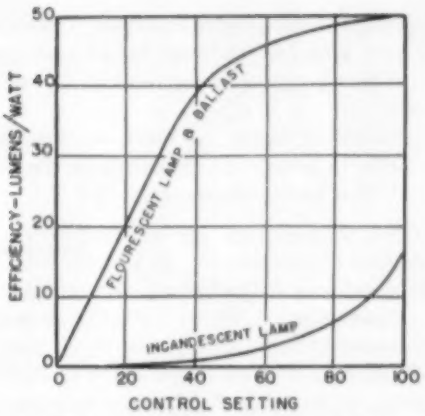

Figure 5. Efficiency of cool white lamp and a 100-watt incandescent lamp in terms of lumens produced per watt of input.

ence. It is located within the ballast housing and permanently connected as shown. This construction of the ballast prevents measurement of the lamp current alone. The voltage shown on the oscillograms was measured directly across the lamp. Referring to the oscillograms, it can be seen that the current is essentially sinusoidal except for short horizontal breaks. Closer inspection of the oscillograms reveals that these breaks in the sinusoidal current wave occur at the time when the voltage is rising or dropping rapidly at a uniform rate. These breaks in the sinusoidal current wave are currents of constant magnitude. They reverse direction when the uniform rate of change of voltage changes sign; flowing in one direction as the voltage is increasing with one polarity, and reversing direction when the voltage is increasing with the opposite polarity. These constant magnitude currents are the currents flowing through the condenser, C_2 which is in parallel with the lamp. The current through a condenser is constant when the voltage applied is changing at a constant rate. When the lamp voltage has increased sufficiently, the lamp conducts and this prevents the lamp (and condenser) voltage from increasing further. The current then follows the approximate sinusoidal wave shape shown.

Brightness Range

This method of brightness control of hot cathode fluorescent lamps can easily achieve a smoothly variable brightness covering a range of over 100 to 1. Fig. 4 shows the variation of lamp brightness and the lamp current versus controller setting. The brightness of a fluorescent lamp, in addition to being a function of lamp current, varies also with the ambient temperature and the age of the lamp. New lamps sometimes experience difficulty

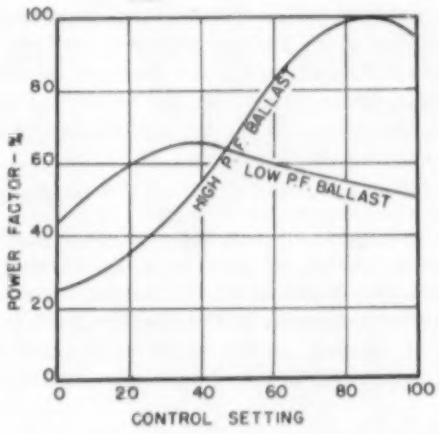

Figure 6. Power factor versus control auto-transformer setting for both low and high power factor ballasts.

in starting and operating at extremely low brightness levels. These difficulties are easily overcome by operating new lamps at normal brightness for a short time. The brightness of the lamp at full dim setting is controlled by means of resistor R_2 (Fig. 1). The brightness of the lamp can be reduced smoothly with stability to conditions of full dimness by this method. The full dim setting is so very dim that it is possible to switch the lamps off without the observer noticing a marked change.

Advantages of Fluorescent Lamps For Dimming Circuits

Fluorescent lamps possess advantages over incandescent lamps in dimming circuits. The efficiency of fluorescent lamps is higher. Fig. 5 shows the efficiency of a cool white lamp and a 100-watt incandescent lamp in terms of lumens produced per

watt of input. The greater efficiency of fluorescent lamps over incandescent lamps has long been recognized. This advantage is apparent in this application also.

As fluorescent lamps are dimmed, they change very little in color. As incandescent lamps are dimmed they become increasingly red.

Power Factor

Fig. 6 shows a plot of power factor versus control auto-transformer setting for both low and high power factor ballasts. The power factor presented here is the ratio of total power input to the ballast and lamp, to the total effective volt amperes input. For the high power factor ballast the power factor increases with increasing lamp brightness approaching unity at the brightest settings. For the low power factor ballast, the power factor increases and then decreases with increasing lamp brightness, being highest at the medium brightness settings. The combined efficiency and power factor of the control unit and lamps depend on the number of lamps being controlled. No effort was made to determine the combined characteristics.

Applications

As might be expected, the greatest demand for dimming control of light is in the theater and stage lighting activities. Fluorescent lamps with controlled brightness are admirably suited to this type of lighting, as well as to many other types such as are used in television studios, hotels, night clubs, auditoriums, display windows, photographic darkrooms and restaurants.

Advantages of New Method

Most of the advantages of this new method of brightness control stem from the simplicity of the system. These advantages are:

(1) The simpler system has lower first cost than more complicated systems.

(2) Maintenance is economical. There are no expensive electronic devices to become defective and cause failure.

(3) The variable ratio control auto-transformer is a standard easily obtainable and replaceable type.

(4) Many lamps can be controlled from a single control auto-transformer. The number of lamps is limited only by the rating of the transformer. Only three leads are needed to connect other lamps in parallel.

(5) In special applications, it may be desirable to combine incandescent and fluorescent lamps on one brightness control unit. This combination is possible with this brightness control unit, which can be used to control all incandescent or all fluorescent lamps if desired.

(6) The brightness of the lamps being controlled by this method can be varied smoothly. There are no sudden changes in the brightness as is the case with some step-wise controllers.

(7) No time delay is needed for warm-up of electronic devices.

500,000,000 CANDLEPOWER searchlight, which tops the modernistic ornamental tower on the roof of the new Republic National Bank Building in Dallas, Texas, is shown here just before it was hoisted to its perch 598 feet above the street. Note the reflection of downtown Dallas on the polished reflector of the 1200-pound lamp. Photo and data courtesy of Federal Sign and Signal Corp., Chicago, Ill.

I.E.S. General Guide to . . .

Photometry

Prepared by the Committee on Testing Procedures for Illumination Characteristics of the Illuminating Engineering Society

Preface

Photometry is one of the fields of measurement seldom treated in detail in physics textbooks. Although the basic physical laws upon which photometry rests are simple, their proper application requires a thorough knowledge of the conditions under which they will yield accurate results.

This report contains descriptions of various types of photometers and photometric methods, and answers some of the more common questions that arise in photometry. The information (much of it published previously scattered throughout a number of periodicals) was correlated and prepared in the present form by Ray P. Teele of the National Bureau of Standards.

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1. Introduction

(a) Undoubtedly investigators have made crude comparisons of light since the first use of fire. However, it was a little over 200 years ago (1729) that Pierre Bouger described what is believed to be the earliest known form of apparatus designed for the comparison of the luminous intensity of two sources of light and laid the foundation for the science of photometry.

Approved by the I.E.S. Council April 1954.

Section 2, Characteristics of the Eye (with Figure 1-4); and **Section 3, Nomenclature and Units** (with Tables I-IV) of the General Guide to Photometry are omitted here but will be included in reprint copies of this report. Sections 6 and 7 will appear in the April issue of ILLUMINATING ENGINEERING.

(b) Photometry is, as its name implies, the measurement of light, that is, radiant energy that is capable of producing in the human eye the sensation of vision. With the exception of various methods of physical photometry, all light measurements are made by the human eye. Even in physical photometry the aim is to obtain an instrument that will give results in accord with those that would be obtained visually.

(c) Since there is a gradual transition from one region to another in the radiant energy spectrum, the principles of photometry may be extended to the ultraviolet and infrared regions adjacent to the visible region.

Section 4—General Guide to Photometry

Basic Principles of Photometry

While photometry, regarded as a physical measurement, depends primarily on two well-known laws (inverse square and cosine law), many people do not sufficiently appreciate the nature of the precautions necessary in practice and the need for taking care of small details to obtain results of the desired accuracy. Stray light and the presence of dirt on the various parts of the photometer are possibly the two main causes of errors. Periodic checks of photometric standards and meters are necessary. Fatigue, temperature effects, lack of linearity, non-conformity to the standard luminosity curve of the human eye, and departures from the cosine law all influence the results obtained with photoelectric photometers. Selective absorption of various components in the optical path should be taken into account. Proper positioning of the optical center with respect to the photometric device and employment of a photometric distance sufficiently great to enable the source to be considered a point are requisites for accuracy.

4.1—*Inverse-square Law*—(a) The illumination of a surface by light emanating from a point source varies inversely as the square of the distance between the source and surface.[7] This can easily be shown to be true if a

luminous point is regarded as the source of a system of spherical waves diverging from it as a center.[7] The spherical area of any such wave as it travels outward from the source must increase as the square of its radius, and since its energy must be regarded as uniformly distributed over its surface, the surface-density of this energy must vary inversely as the square of the radius of the wave (that is, the square of the distance from the source).

(b) The inverse-square law holds good only when the light source is relatively small with reference to the distance from the source to the illuminated surface. Many instances arise in practice where the dimensions of the source cannot be regarded as negligible compared to the distance at which measurements are made. In the case of a perfectly diffusing radiating circular disk of radius r the flux received by a parallel and coaxial element of area b is $\pi b B r^2/(d^2+r^2)$, where B is the normal candlepower per unit area of the disk, that is, its photometric brightness, and d the distance between the disk and elementary receiving area.[9] This differs from the result that would be calculated by the inverse-square law, namely, $\pi b B r^2/d^2$ by the factor $d^2/(d^2+r^2)$. Hence the value of the luminous intensity measured at a finite distance may be reduced to the true intensity ($d=\infty$) by multiplying by the factor $(d^2+r^2)/d^2$ (see Fig. 5).

(c) For approximately rectangular sources, such as the filament of a projection type lamp, results may be corrected or the magnitude of the error determined by considering the circumscribing disk for the rectangular source.

(d) For the purpose of determining corrections to the inverse square relationships, sources such as fluorescent lamps may be considered as perfectly diffusing radiating cylinders of radius a and length $2l$.[8] The radiation from such a cylinder to an elementary surface at a distance d from the axis of the cylinder, and located on and perpendicular to a line passing through the center of the cylinder and perpendicular to its axis is[8]

$$\frac{2B}{d}\left[a\cos^{-1}\frac{d^2-a^2-l^2}{d^2-a^2+l^2}+l\left(\frac{q+1}{q}\cot^{-1}\sqrt{\frac{p}{q}}-2\cot^{-1}\sqrt{p}\right)\right]$$

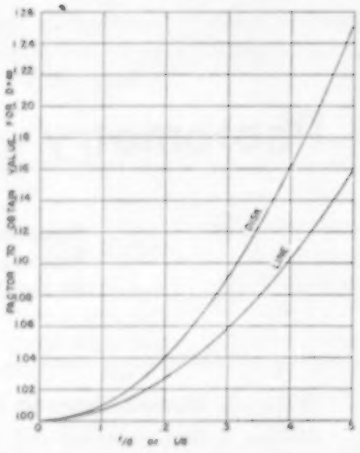

Figure 5. Factor for obtaining candlepower for $D=\infty$. It is seen that for the error to be less than 1 per cent it is necessary to use distances that are greater than 10 times the maximum dimension of the source.

where $p=\dfrac{d+a}{d-a}$

and $q=\dfrac{(d+a)^2+l^2}{(d-a)^2+l^2}$

The equation gives results which agree with experimental data.

(e) Often a is small compared to d and the cylinder may be regarded as a strip of breadth $2a$ and length $2l$ in which case the above reduces to $[2aB/d][\tan^{-1}l/d+ld/(l^2+d^2)]$. This differs from the result which would be calculated by the inverse-square law, namely, $4alB/d^2$ by the factor $[d/2l][\tan^{-1}l/d+ld/(l^2+d^2)]$. Hence the value of the luminous intensity measured at a finite distance may be corrected to the true intensity ($d=\infty$) by multiplying by the reciprocal of this factor.

(f) Both of the corrections treated above are less than one per cent when r/d or l/d is less than 0.1 (note that l is the semi-length of the strip source). These corrections are plotted in Fig. 5.

4.2—*Cosine Law* (Lambert's Law)—**(a)** The luminous energy received by a plane surface varies as the cosine of the angle between the normal to the surface and the incident ray.[7] This can be seen by again considering the point source of light as the source of a system of spherical waves diverging from it as a center.[7] Since the direction of motion is always perpendicular to the wave front, it follows that an elementary area can receive energy only in proportion to its area projected in that direction; that is, the surface density of the energy received by any such area is proportional to $\cos\theta$, where θ is the angle between the normal to the surface and the direction of propagation of the incident wave. The cosine law applies to any plane surface, so far as the incident light is concerned.

(b) Another "cosine law" is named after Lambert and applies to the emission (by reflection, transmission or self-luminosity) of a perfectly diffusing surface and may be stated as follows: A perfectly diffusing surface is one for which the luminous intensity from a given area in any direction varies as the cosine of the angle between that direction and the normal to the surface. Under this condition the intensity per unit of projected area is constant and the surface appears equally bright whatever the direction from which it is viewed.

4.3—*Combined Law*—(a) The basic laws apply to plane surfaces only if both source and surface be small compared to the distance between them. Unfortunately, in practical illuminating engineering this ideal is seldom realized. When it is impossible to consider the plane surface as small in comparison with the distance between the source and surface it is necessary to calculate the illumination from the general formula, $E_H=I_\theta\cos^3\theta/h^2$. In this formula I_θ is the luminous intensity of the source in the direction defined by θ and h is the vertical height of the source above the plane. (The part $\cos^2\theta/h^2$ results from the inverse-square law, being $1/d^2$ for the point, and the remaining cosine is from the cosine law.) If a number of sources contribute to the illumination at a given point on the plane, the total illumination is the summation $\Sigma I_\theta\cos^3\theta/h^2$ for all sources.

(b) If the illumination on a plane perpendicular to the direction θ (the normal plane) is desired, the equation is $E_N=I_\theta\cos^2\theta/h^2$, while the equation for the illumination on the verti-

cal plane is given by $E_V = I_\theta \cos^2 \theta \sin \theta / h^2$ where θ is the angle between the vertical plane and the direction θ.

4.4—***Talbot's Law***—**(a)** If a disk with one or more angular apertures in it is rotated between a source and a surface so that light reaches the surface for only a certain fraction of the time, and if the rotation is so fast that the eye perceives no flicker, the effective photometric brightness of the surface is reduced in the ratio of the time of exposure to the total time. The reduction is by the factor $\theta/360$, where θ is the total angular aperture in degrees. The sector disk has advantages over absorbing media in that its transmission is not altered over a period of time and reduces luminous flux without changing the spectral composition.

(b) A sectored disk must be used with caution to avoid stroboscopic effects with flickering or cyclic light sources (some gaseous discharge sources) and when some types of photoelectric receivers and amplifiers are employed.

4.5—***Attenuating Filters and Screens*** — Other means of reducing intensity are by wire mesh gratings, partially silvered mirrors, diaphragms and neutral filters.

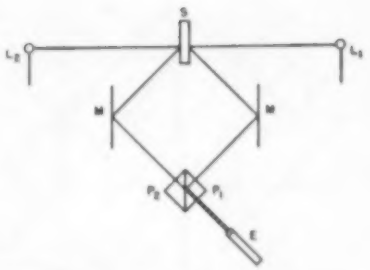

Figure 6. Paths of light in a Lummer-Brodhun photometer. Light from the sources being compared illuminates opposite sides of the photometer screen *S*. These sides are viewed in juxtaposition by means of the mirrors *M* and the photometric cube P_1P_2.

Section 5—General Guide to Photometry

Photometers

5.1—***Visual Photometers***—In visual photometry, the eye is used to compare the photometric brightnesses of two surfaces and usually to adjust them to equality. Because of its power of adaptation to different brightnesses, the eye cannot *measure* light with any degree of accuracy. An observer can, however, judge quite accurately when two surfaces viewed simultaneously side by side are equally bright, provided they have nearly identical chromaticities (color). If the eye is required to decide when equality of photometric brightness or equality of contrast exists between the comparison surfaces of different chromaticity (color), it encounters a difficulty which increases as the chromaticity difference becomes greater.

5.1.1—*Bunsen Grease Spot*—The simplest photometer head would consist of two surfaces, each of which receives light from only one of two sources being compared, mounted in close proximity to each other. One of the oldest types of photometer head which is still in limited use is the Bunsen "grease-spot" head. This head consists of a piece of thin opaque white paper, with a translucent spot obtained by treating the paper locally with oil or wax, mounted between the sources to be compared and at right angles to the line joining them. Two mirrors mounted so that images of the two sides are seen in close proximity, side by side, complete the Bunsen head. Sometimes a prism system is used to bring the images of the two sides of the disk closer together than can be done with mirrors.

5.1.2—*Lummer-Brodhun* — The Lummer-Brodhun photometer head is the one that is now most commonly used for precise visual photometry. In this head an opaque screen, both sides of which are white diffusely reflecting surfaces, is viewed through a set of prisms, referred to as a Lummer-Brodhun cube or often simply as "the cube," and mirrors (or totally reflecting prisms) so that the two sides are seen in juxtaposition by the eye of the observer. Fig. 6 shows the paths of light in a Lummer-Brodhun head. L_1 and L_2 are the two sources of light, S is the opaque screen, M and M are two mirrors or totally reflecting prisms, P_1 and P_2 are the prisms which comprise the cube and E is an eyepiece lens. Two types of cubes are used, one for equality-of-brightness comparisons, usually presenting two concentric ellipses (concentric circles viewed at 45 degrees), and one for equality-of-contrast comparisons which present a pattern to the eye. The details of the more complex equality-of-contrast cube are shown in Fig. 7. The two prisms forming the cube are in optical contact over the portions through which light reaches A and a. The light reaching a has to pass through the contrast strip C_1, a piece of optical glass which by reflection removes about 8 per cent of the light. Where the two prisms are not in optical contact reflection takes place, and light reaches B and b, passing through a contrast strip C_2 before reaching b. This results in an appearance of the field as shown in the lower right-hand portion of Fig. 7. When the photometric brightnesses of the two surfaces being compared are the same, the two halves A and B have the same brightness and at the same time the trapezoids a and b stand out in equal contrast to their backgrounds.

5.1.3—*Martens Polarization Photometer* — **(a)** The Martens polarization photometer employs a Fresnel biprism to obtain contiguous images of the surfaces to be compared. In Fig. 8 this type of photometer is shown diagrammatically; a and b are the surfaces of which the brightnesses are to be compared. The light from a passes through a plano-convex lens C into a Wollaston prism W. Here it is split into two beams: one polarized in the plane of the paper and shown by the full line in the figure, the other one polarized in a plane perpendicular to the paper and shown by the broken line in the figure. It then passes through the Fresnel biprism F. The light from b is treated similarly and the angle of the biprism is designed so that images of a and b oppositely

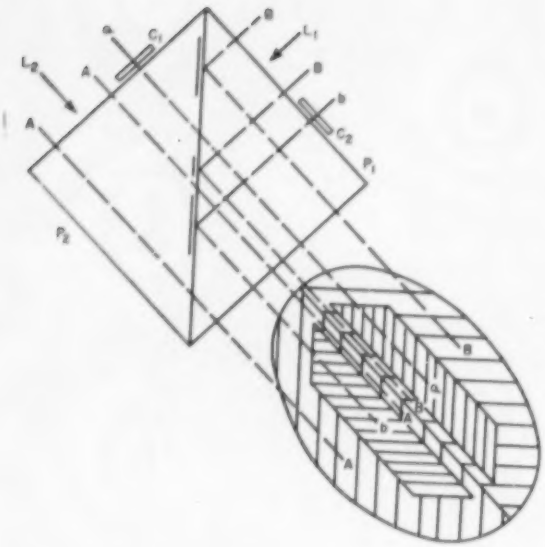

Figure 7. (left) Details of equality-of-contrast cube and appearance of field. The two prisms forming the cube are in optical contact over the portions through which light reaches *A* and *a*. The light reaching *a* has to pass through the contrast strip C_1, a piece of optical glass which by reflection removes about 8 per cent of the light. Where the two prisms are not in optical contact reflection takes place, and light reaches *B* and *b*, passing through a contrast strip C_2 before reaching *b*. At a photometric balance, when the two halves *A* and *B* have the same brightness, the trapezoids *a* and *b* stand out in equal contrast to their backgrounds.

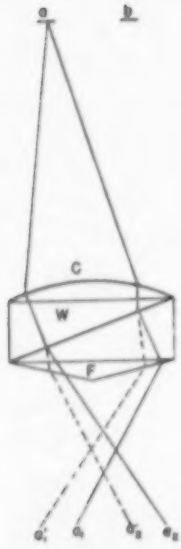

Figure 8. Schematic arrangement of polarization photometer. Light from a source *A* passes through a plano-convex lens into a Wollastan prism *W*. Here it is split into two beams, one polarized in the plane of the paper (full line) and the other polarized in a plane perpendicular to the paper (broken line). Light from the other source *b* is treated similarly. The angle of the biprism is designed so that images of *a* and *b* oppositely polarized are contiguous at the eye, after passing through an analyzing Nicol prism. The analyzing Nicol prism is rotated to obtain the photometric balance.

polarized are contiguous at the eye, after passing through an analyzing Nicol prism. The unused images are stopped by a diaphragm. The analyzing Nicol prism in the eyepiece interposed in the path of these beams will reduce one image by the factor $\cos^2\theta$ and the other by the factor $\sin^2\theta$. If θ is the angular position for a photometric balance, the ratio of the photometric brightnesses of the two images, with no Nicol prism interposed, would be $\tan^2\theta$.

(b) Some absorbing media, such as certain plastics, polarize light. Obviously, if such a material is placed haphazardly in the path of one of the beams entering a Martens photometer, the reading of the photometer will not be correct. The amount the reading is in error will depend upon the polarizing ability of the specimen and there is no simple way of determining the exact magnitude of the error. If, however, the plane of polarization of the material is placed at 45 degrees to the planes of the analyzer, the reading is closely that for unpolarized light.

5.2—*Photoelectric Photometers*— Photoelectric photometers may be divided into two classes, (1) barrier-layer photoelectric cells, which do not require a battery for operation and (2) photoelectric tubes which require a battery or external power supply for operation.

5.2.1—*Barrier-Layer Cell Meters*—**(a)** Barrier-layer cell receivers produce a current when radiant energy is incident on their sensitive surfaces and require only a sensitive microammeter, preferably of comparatively low resistance (100 ohms), to measure the current from them. The current is of the order of 1 or 2 microamperes per footcandle. The cells depart from linearity of response to radiant flux as the resistance of the meter (or circuit) to which they are connected is increased. Several manufacturers make microammeters, with several ranges, having the same resistance for all ranges, namely, about 100 ohms. These suffice for many purposes where an error of only a few per cent can be tolerated. For more precise results more sensitive meters or galvanometers are necessary as well as special precautions to avoid fatigue and thermal effects. A circuit suitable for more precise measurements has been published.[10] This circuit was developed from an earlier one, the essential elements of which are shown in Fig. 9.[11] The circuit is a current-balancing circuit giving, in effect, at balance, zero external resistance in series with the barrier-layer cell, *B*. When radiant energy is incident on the barrier-layer cell a current is produced by the cell. The circuit is adjusted until a balance is indicated by zero deflection of the galvanometer. Under this condition the current i_3 in the resistance r_3 and the current output of the photoelectric cell are equal and, with r_3 kept constant, are proportional to the poten-

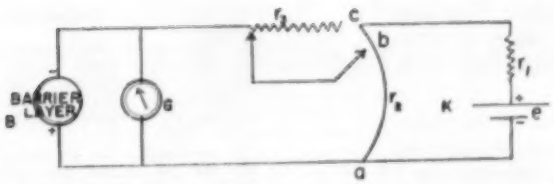

Figure 9. A circuit suitable for precise measurement of barrier-layer cell output. The circuit is a current-balancing circuit giving, in effect, at balance, zero external resistance in series with the photoelectric cell *B*. The galvanometer *G* is of the high current sensitivity type. *K* is a Kohlrausch slide wire having resistance r_2; *e* is a 1.5-volt dry cell; r_1 is a 100-ohm resistor and r_3 is a variable resistor preferably a decade box with a stop so that its value is never less than 1000 ohms. The resistance of the leads from the barrier-layer cell to the galvanometer must be negligibly small.

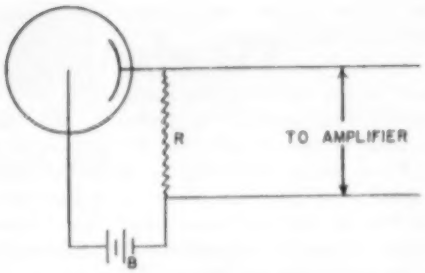

Figure 10. A circuit suitable for measurement of photoelectric tube output. The simplest circuit consists of a battery, a suitable meter and the photoelectric tube in series. The sensitivity of such a circuit is low and it is often necessary to measure the voltage drop across a resistance (of the order of megohms) with some type of amplifier.

tial difference between points *a* and *b*. The potential difference between *a* and *b* is nearly proportional to the resistance, *r*, between points *a* and *b*. The degree of approximation may be determined from the following expression for the current, i_3:

$$i_3 = \frac{vy}{y\,(r_1+r_2) - y^2 r_2 + r_3 + \dfrac{r_1 r_3}{r_2}}$$

where $y = r/r_2$ and *v* is the voltage of the dry cell, *e*. If *v* is constant the maximum error may be determined by finding the maximum variation in the denominator of the expression for i_3. In all cases where r_1 is greater than r_2 this maximum error in assuming proportionality between *r* and i_3 is $100 r_1 r_2/(r_2 r_3 + r_1 r_3)$ per cent. For the circuit given the maximum error is less than 0.1 per cent for values of r_3 greater than 7000 ohms and for r_2 equal to 7 ohms (normal Leeds & Northrup Kohlrausch slide wire).

(b) The accuracy obtained with barrier-layer cells will be influenced by the care used in calibrating the Kohlrausch slide wire employed in the above circuit. In addition, the linearity of the cell response for zero external resistance must be carefully determined. The effect of temperature and the fatigue characteristics of the cell must also be ascertained. When careful calibration has been made and precautions are taken to avoid, correct for or compensate for fatigue, results that are precise to better than one-half of one per cent can be obtained.[12]

(c) The spectral response curve of the photoelectric cells is quite different from that of the human eye and the degree to which they are corrected by filters to duplicate the luminosity curve of the eye will govern the approximation to which their response may be taken as a measure of light. In general, photoelectric receivers of all types have spectral response curves that are individual, being different for cells or tubes of the same type and manufacture, so that each particular receiver must be separately corrected. Some indication of expected variations from cell to cell may be found in a paper by A. E. Parker.[13] A cell can, of course, be used to compare the radiant energy from sources having identical spectral distributions without the correcting filters.

5.2.2—*Photoelectric Tube Meters*—**(a)** Photoelectric (photoemissive) tubes, like the barrier-layer cells, must be properly filtered to duplicate the standard luminosity curve of the eye before they can be considered to measure light.

(b) Photoelectric tubes are usually employed with an amplifier to obtain the desired sensitivity. The simplest circuit consists of a battery, a suitable meter and the photoelectric tube in series. The sensitivity of such a circuit is not sufficient and a circuit similar to that of Fig. 10 is employed. The resistance of *R* is of the order of megohms while the voltage of the battery *B* is that recommended by the manufacturer of the tube and is of the order of 90 to several hundred volts (often obtained by using radio B batteries). The photoelectric current also may be measured by either a galvanometer or electrometer.

(c) The photoelectric tube and frequently the first tube of the amplifier need to be mounted in an airtight box containing a drying agent to prevent leakage due to moisture on the surface of the photoelectric tube and grid lead of the amplifier tube.

(d) The "dark current," the current passing through the tube when it is not illuminated, must be taken into consideration. Part of this current may be due to leakage over the surface of the tube and can be eliminated by a guard ring, for some types of tubes, or by placing the tube in a box containing a drying agent. The true dark current, the remainder after the leakage has been eliminated, can be compensated for by some electrical means or by subtracting it from the observed current when the cell receives energy. Another simple means of eliminating the effect of the dark current is the use of a shutter and taking "light-off" and "light-on" readings.

5.3—*Radiometric Photometers*—(a) In radiometric photometry some type of radiometer (thermocouple, thermopile, bolometer or other radiometric detector) is used to measure the radiant flux in the visible spectrum. Receiving surfaces which are nonselective to a sufficient degree throughout the visible range are readily available. A filter that duplicates the standard luminosity curve and may be prepared by anyone has been described.[14] This consists of three components — two glass elements and a solution to be used in a 5-centimeter absorption cell. This filter and a non-

selective receiver may be used to measure light with high accuracy.

(b) Another method that has been successful is the use of a luminosity template.[15] This template is placed in the path of the radiant flux dispersed by a prism, and must be of such shape that the percentage of radiant flux at each wavelength that is allowed to pass is proportional to the standard luminosity factor at that wavelength corrected for any selectivity in the spectral transmittance of the optical system. The radiant flux in the recombined beam is then exactly proportional to the luminous flux. This method may be extended to take the selectivity of the receiver into account, provided the spectral response is constant over a period of time.

(c) Radiometers respond to radiant flux outside of the visible range as readily as to that in the visible range and, consequently, require very careful shielding from such invisible flux. In the design of a luminosity filter it is accordingly necessary that all radiant flux outside the visible spectrum be completely eliminated. This may be accomplished by means of ultraviolet and infrared absorbing glass filters.

(d) The radiant flux in the visible spectrum after passing through the luminosity filter or template is only a small percentage of the total flux from most sources; one of the difficulties of radiometric photometry is the measurement of the very small electrical quantities (current or voltage) that are produced. These difficulties (which are common to all measurements of small voltages or currents) include the susceptibility of the sensitive galvanometer of mechanical disturbance, drift of zero, and, unless a null or equal deflection method is used, the lack of exact proportionality between current or voltage and deflection. Variation in ambient temperature causes uncertainty of the zero of the thermopile-galvanometer system but this may be practically eliminated, if erratic rapid fluctuations are avoided, by taking two zero readings at equal intervals of time before and after the deflection reading.

I.E.S. Regional Conferences—1955

Southern	**Fort Harrison Hotel** **Clearwater, Florida**	**March 31-April 1**
Southwestern	**Gunter Hotel** **San Antonio, Texas**	**April 3-6**
Inter-Mountain	**Westward Ho Hotel** **Phoenix, Arizona**	**April 11-13**
South Pacific Coast	**Statler Hotel** **Los Angeles, California**	**April 13-15**
Pacific Northwest	**Harrison Hot Springs Hotel** **Harrison Lake, British Columbia**	**April 25-27**
Midwestern	**Edgewater Beach Hotel** **Chicago, Illinois**	**May 2-3**
Canadian	**Mount Royal Hotel** **Montreal, Quebec**	**May 12-13**
East Central	**Abraham Lincoln Hotel** **Reading, Pennsylvania**	**May 19-20**
Northeastern	**Fort William Henry Hotel** **Lake George, New York**	**June 10-11**

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Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of H. F. Davidson, has prepared this answer to a question on lumen maintenance of fluorescent lamps. Readers are invited to submit similar questions of general interest to be considered for publication. Questions should be sent to the Society Headquarters

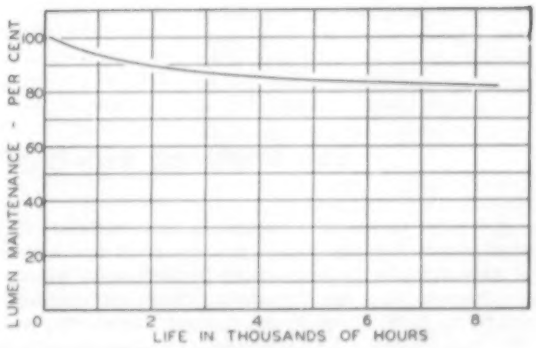
Lumen Maintenance of Fluorescent Lamps

Fluorescent lamps, in common with nearly all other light sources, depreciate in light output as a function of operating time. According to the best information available at present, there are three basic causes for this depreciation. All three factors appear to be mono-molecular chemical reactions. All three reactions proceed concurrently but each has a particular rate of reaction independent of the other two. In other words, the loss of luminous efficiency in a fluorescent lamp proceeds exactly as if there were three types of impurities, present in greater or lesser amount in the lamp, with each having an injurious effect on the fluorescent properties of the phosphor.

The first cause of loss is of a type that might be expected to result from impurities which are of a gaseous nature that may combine with the mercury vapor to lay down an absorbent layer over the phosphor. Such a layer, for example an oxide of mercury, would hinder the ultraviolet from the discharge reaching the active centers of the phosphor and thereby reduce the light output.

The second cause appears to be due to what the chemist would call a "solid phase" reaction and which proceeds at a much slower pace than the gas phase reaction. Examples are the chemical reactions that might take place between the phosphor and the glass wall of the lamp or impurities present in the phosphor itself.

The third cause of loss which is of concern is believed to be photochemical in nature and usually takes place very slowly. This is a deterioration of the phosphor itself, resulting from the action of the ultraviolet radiation. Experiment shows that it is the 184.9 millimicron radiation which is responsible in large measure for this final loss in phosphor efficiency.



Lumen maintenance of T12 lamps.

The results of the three reactions may be stated mathematically by the following equation:

$$L_o - L_t = A\,(1 - e^{-at}) + B\,(1 - e^{-bt}) + C\,(1 - e^{-ct})$$

where L_o = initial efficiency in lumens per watt
L_t = efficiency at time t
t = operating time in hundred-hours
A, B and C are representative of the amount of impurities present and have the dimensions of lumens per watt
a, b and c are quantities which represent the velocities at which the reactions approach completion.

With present-day methods of processing and the stabilized phosphors now in use, these quantities have the following approximate values for T12 lamps operated at 425 ma:

$A = 0.5\text{-}1.0$	$a = 4.0$
$B = 3.0\text{-}5.0$	$b = 0.2$
$C = 8.0\text{-}12.0$	$c = 0.02$

Fig. 1 illustrates the lumen maintenance which may be expected from today's T12 lamps. This curve is valid for both 40-watt T12 and 96-inch

T12 white or cool white lamps operated at 425 ma. Changes in lamp loading should increase or decrease the values of the exponents of the maintenance equation proportionately; experimental evidence supports this contention.

The depreciation of fluorescent lamps is discussed in more detail in a number of technical papers some of which are listed below.

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Low Brightness with High Levels in Engineering Office

A modular system of self-contained units, including the vinyl plastic diffusing panels, provides 65-70 footcandles at work areas in the Engineering Department of Barrett Construction Co., San Francisco. The basic luminaire design, by C. W. Macy, Pacific Gas and Electric Co., San Francisco, is for a low-brightness unit — not exceeding 333 footlamberts at any spot on the fixture surface between 0 and 90 degrees — which is suitable for low-ceilinged areas as well as for conventional ceiling heights. With an over-all vertical drop of 5½ inches, surface-mounted, the modular units are here butted together in a rectangle.

A rough rule-of-thumb reported by Mr. Macy for computing illumination with conventional ceiling heights is:
⅓ of ceiling area covered — 50 footcandles
½ of ceiling area covered — 75 footcandles
All ceiling covered (luminous ceiling) — 150 footcandles.

In this relatively clean location, a maintenance factor of 0.80 is estimated by the designer, due to the minimum of air movement within the luminaire.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

I.E.S. Gold Medal Awarded to J. L. Stair

J. L. Stair

The Society's highest honor, its Gold Medal and certificate, has been awarded to J. L. Stair by unanimous approval of Council, acting on recommendation of the Gold Medal Award Committee. The Medal, top award in the illumination field, is "for meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering."

Mr. Stair's achievements in lighting have been both outstandingly meritorious and conspicuously influential to the art. All of his work, and particularly in the field of applied illumination, has shown a constructive combination of engineering talent and creative grace. A pioneer in effective lighting ideas, materials, and methods, Mr. Stair was for nearly thirty years an acknowledged leader in the design of equipment, for which he holds many patents, and a creator of lighting techniques. Many hundreds of his original installations and equipment designs have provided a strong stimulus to the advancement of the lighting art. Much of his work has been detailed in numerous papers in the Society's Transactions throughout the years and in several well-known books he has written on the subject of applied lighting.

Prior to his retirement in 1948, Mr. Stair was Chief Consulting Engineer with the Curtis Lighting Company, Chicago, joining that firm in 1911. His service to the Illuminating Engineering Society has been equally valuable, and almost as long. A member since 1916, Mr. Stair has held almost every elective office, local, regional and national, and was President of the Society in 1933-1934. In addition he has been member or chairman of over thirty I.E.S. committees and has been an active supporter of C.I.E., serving as a delegate in 1935 at the Congress in Berlin. In this connection it is significant to note that when the highest grade of Fellow of I.E.S. was established in 1945, Mr. Stair was among the ten men chosen to be the Society's first Fellows. He has since been elected also to the grade of Member Emeritus, on his retirement from active business, in further recognition of his outstanding service.

Formal presentation of this latest honor to Mr. Stair will be made during the opening session of the I.E.S. National Technical Conference in Cleveland next September.

Summary of Action Taken at February Council Meeting

President Duncan M. Jones presided at the regular meeting of I.E.S. Council February 10, held at the Lexington Hotel in New York City. Thirty-four members and visitors were present as follows: Past Presidents of the Society E. M. Strong and A. H. Manwaring; Vice-Presidents, R. F. Hartenstein and M. N. Waterman; General Secretary Kirk M. Reid; Treasurer George J. Taylor; Directors C. C. Shotwell, W. A. Stannard, L. C. Twichell, S. H. Hazleton proxy for John S. Walsh, J. F. Whitehead, Jr., F. C. Winkler; Regional Vice-Presidents C. J. Berry, L. R. Anderson proxy for G. B. Buck II; J. R. Chambers, W. F. Little proxy for Dan M. Finch, M. B. Hastings, C. W. McCormick, Martin J. Myers, Jr., Glenn E. Park, Blair E. Plowman, A. C. Sangster; Executive Secretary A. D. Hinckley; Technical Director C. L. Crouch; Ruby Redford, Editor; C. E. Ellis, Advertising and Promotion Manager; W. W. Booth, S. G. Hibben, Paul H. Hildebrand, C. N. Laupp, W. F. Lowell, Joseph Thomas and R. S. Wiseman.

Results of two interesting financial studies were presented to Council by Kirk Reid, last year's Treasurer, and Warren Booth, Finance Committee Chairman. One involved a new form of accounting, suggested by the auditors; the other a report on a cost-per-member study undertaken by the Finance Committee. All concerned with the Society's fiscal problems urged further study aimed at strengthening reserve and research appropriations.

Committee appointments were proposed (and approved) for a number of the Society's technical committees. A complete, up-to-date list of all committee personnel will be published in the April issue of ILLUMINATING ENGINEERING. One task committee already appointed was asked to increase its scope to include the study of expansion of headquarters staff as well as the study of future location and space requirements.

NATIONAL CONFERENCE

Charles Laupp, National Conference Chairman submitted for Council approval, outline of the Cleveland program and budget. Their proposals were accepted. Mr. Laupp also reported on Boston plans which are well underway. A separate budget for Golden Anniversary activities at the 1956 Conference was also considered.

NEW ELECTIONS

Seventy-three new Associate Members were reported by the General Board of Examiners, as well as 10 Student Member elections. Council took action on the Board's recommendation, electing 5 Members. Names, by Section and Chapter, of all new members elected at the February Council meeting are given in the back pages of this issue.

By favorable action of Council on the Board's recommendation, Mr. A. I. Benedict, long-time active member of the Southern California Section and the San Diego Chapter was elected to Member

(Council Summary continued on page 8A)

Here and There With I.E.S. Members

Charter of Section status was presented to the Indiana Chapter, now Section, at a recent meeting. In photo at left,

Section Chairman Ralph Crockett receives the Charter from the Midwestern Region V-P, James Chambers.

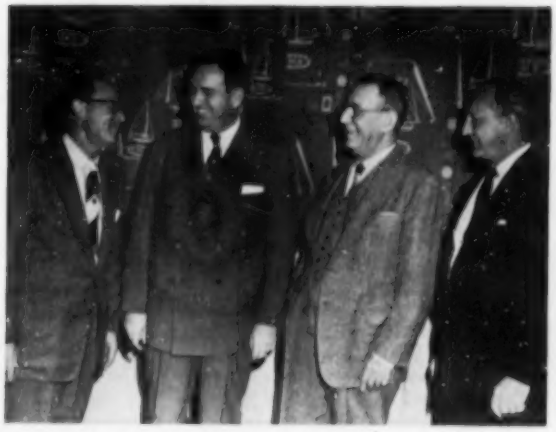
Guest speaker at the January 27 meeting of the St. Louis Section, at the Hotel Gatesworth, was R. G. Slauer, who discussed "Six Key Lighting Jobs — and Why." At the head table, left to right, are: O. S. Wilkins, Program Chairman; A. W. Felt, Papers Reporter; E. C. Ryan, Board of Managers, R. G. Slauer, speaker; Brooks Chassaing, Section Chairman; H. J. Poehling, Board of Managers; Willis Mangold, Data Sheet Chairman; and T. P. Gleeson, Reception Committee.

Panel discussion on Light in Industry was the highlight of the January 31 meeting of the Eastern New York Chapter, at the Circle Inn, Latham, N. Y. Panel moderator, J. L. Ottenheimer, consulting engineer, is shown here, standing. Panel members, seated, from left to right are J. M. Schmidt, General Electric, M. J. Herlt, West Virginia Pulp and Paper Co. and W. P. Hardin, Behr-Manning Corp. Sound pictures were taken for presentation on WROW-TV.

Following an address by Carl Zersen, director of the Chicago Lighting Institute, at the Northern College of Optometry in Chicago, several students gathered around to ask more questions. Pictured here, from left to right, are Stanley Herr, Earle Hunter, Richard Brauer, Mr. Carl Zersen, James Gallagher, Clifford Wilson and Edward Choryan. Mr. Zersen discussed the common problems of vision specialists and lighting engineers.

Just on the verge of becoming an I.E.S. Chapter (Suwanee River) members in northern Florida and southern Georgia met in Valdosta, Ga., January 27. Speaker for the evening was Dr. Theodore Wilder, Optometrist from Griffin, Ga., whose topic was "Light and Sight."

Attendance was 130 at the Residence Lighting Workshop, sponsored February 2 by the Michigan Section's Residence Lighting Forum (for program, see page 7A, February IE). Shown here are: l. to r., Mary Webber, General Electric Co., speaker; Lou Schneider, Electrical Association of Detroit; Bert Smith, Smith Brothers Electric Co.; and Gertrude Capps, of Detroit Public Schools.



A cost and comfort appraisal of 13 types of recessed lighting systems was the topic of guest speaker James Whitehead, of Day-Brite Lighting Inc., at the February meeting of the New Orleans Section. In the photo are, left to right, Jake M. Gensburger, Section Program Chairman; Mr. Whitehead; Arthur A. Levy, New Orleans Section Chairman; and Conrad Berdon, Liaison Chairman.

Members of the Quebec Chapter at their February 10 meeting heard P. E. Larose, Professional Engineer of the Quebec Power Co., who spoke on the Quebec Electrical League, the Red Seal program and Adequate Wiring in the Home.

Emeritus. Mr. Benedict, now retired from the San Diego Gas and Electric Co., was so honored for his many years of active service in I.E.S. aims.

Following current elections and other changes, the membership of I.E.S. to date was shown to be:

September 30, 1954		February 10, 1955
8020	Total Membership	8085
34	Members Emeritus	35*
78	Fellows	78
1954	Members	1958
5723	Associate Members	5791
231	Student Members	223

*Includes 12 Fellows.

Regional Activities

Eight of the ten Regional Vice-Presidents of I.E.S. were present at Council meeting. Each reported on activities underway in his Region. Marshall Waterman, Chairman, presented recommendations covering a number of matters studied by this committee, at their meeting February 9. Council accepted their recommendations, which included:

(1) Change of name for the Oklahoma Chapter, which will hereafter be known as the Oil Capital Chapter. Change was requested to avoid confusion with the new Central Oklahoma Chapter.

(2) A boundary change was approved for the Puget Sound and Oregon Sections, transferring five counties to Oregon's area.

(3) The proposal to divide the Southern Region into two separately administered areas was reported not acceptable to two of the Chapters involved and the problem of satisfactorily covering this Region with one Vice-President was assigned to further study. Council approved the committee's proposal that an assistant be appointed October 1 to aid the Southern Regional Vice-President in the administration of the western part of the Southern Region .

(4) Mr. Waterman reported that all nine Regional Conferences for 1956 are definitely scheduled, and hotels reserved.

(5) The committee studied proposals in connection with certificates to retiring Section and Chairmen and recommends their continuance.

(6) A group of members in Valdosta, Georgia will have met all requirements for a Charter petition by the time Council Executive Committee meets in March. On recommendation of the Regional Activities Committee, Council delegated authority to the Executive Committee for approval of Charter then for the new chapter, to be known as the Suwanee River Chapter.

(7) On recommendation of the Committee, Council approved the enlargement of the Society's liability insurance to cover claims which might arise from accidents occurring at all I.E.S. meetings, national, regional and local.

(8) Approval of a petition from the Western Michigan Chapter in Grand Rapids, gave Section status to this group.

Technical Activities

Highlights of what's going on in the Society's technical program were given to Council by C. L. Crouch, Technical Director. He mentioned especially progress toward a new office lighting practice being studied by that committee. Recent A.S.A. approval of standards for reflectance of office furniture and equipment, and unanimity of thinking of school and office people on brightness recommendations may bring completion of a new Office Lighting Practice soon.

Two reports presented by Mr. Crouch were accepted for letter ballot. These are: Report on Nomenclature, and Lighting of Saw Mills, Part II.

Public Relations

J. F. Whitehead, Jr. reported a number of recommendations reached by this committee at two recent meetings. Some of these included the establishment of a task committee to develop a special emblem for the I.E.S. 50th Anniversary, special Anniversary local programs, reunion of all past chairmen at special Anniversary meetings, a news letter to all members, and further changes in the rules of the M.M.I.L.J. contest.

In connection with both public relations and the I.E.S. anniversary it was noted that Willard Brown, of General Electric Co., Cleveland, had accepted chairmanship of a special committee to coordinate anniversary activities.

Research Fund

A comprehensive report of Lighting Research in 1954 was presented for the I.E.S. Research Fund Trustees by E. M. Strong, Research Executive Committee Chairman. In this connection, Professor Strong outlined to Council the need for additional support of this program, for the provision of basic information vital to the protection of the lighting profession. He noted that 22 projects have been initiated and largely completed in the ten years of the Research Fund's operation and expressed pride in the heightened stature the Society has gained by reason of the work of the Fund. Copies of the Annual Research Report, showing current progress on projects now underway are available from Mr. Crouch's office.

South Pacific Coast Regional Advances Opening Date

The opening session of the South Pacific Coast Regional Conference has been advanced to the evening of April 13, to accommodate the full schedule of papers and activities planned. The conference is being held at the Hotel Statler in Los Angeles, Calif.

At this first session, the conference will be officially opened by F. Jack Rohring, General Chairman, and the National Officers will be introduced. E. W. Biscailuz, Sheriff of Los Angeles County will welcome the delegates. Featured speaker for the evening meeting will be Eugene W. Beggs, Westinghouse Electric Corp., Bloomfield, N. J., who will give the presentation of the Lighting Progress Report. Edwin Blair, Chairman of the host Southern California Section, will preside.

The preliminary program announced for the two following days, April 14 and 15, will consist of the following technical sessions.

April 14, Morning

James E. Barnes, *Chairman*,
Northern California Section, presiding

Points of View of Traffic Safety — Oscar Meissner, City of Los Angeles, Chairman. L. M. K. Boelter, Dean of Engineering U.C.L.A., Panel Discussion Leader.

A Governmental Leader — Introduction of I.E.S. President, Duncan M. Jones.

The President's Message — D. M. Jones.

Light Marches On — Dr. E. F. Lowry, Sylvania Electric Products, Inc. and I.E.S. Gold Medallist.

April 14, Afternoon

William J. Flynn, *Chairman*,
Mother Lode Chapter, presiding

Garden After Twilight.

Lighting for Indoor Living.

My Most Interesting Lighting Job Contest — Harold Strahn, Contest Committee Chairman

April 15, Morning

J. W. Howard, *Chairman*,
San Diego Chapter, presiding

Light Sources — Kirk M. Reid, General Electric Co., Cleveland, Principal Speaker and Panel Discussion Leader.

New Standards and Trends in Industrial Lighting — Benjamin Benson, Benjamin Electric Mfg. Co., Des Plaines, Ill., Principal Speaker and Panel Discussion Leader.

Floodlighting — Ted Shepherd, Panel Discussion Leader.

April 15, Afternoon

Gene Smith, *Chairman*,
San Jose Chapter, presiding

School and Office Lighting.

Lamp Auxiliary Equipment — E. H. Salter, Electrical Testing Laboratories, New York, N. Y.

Lighting for Merchandising.

President Jones Appointed Member Of IAEL Advisory Committee

IES's President D. M. Jones has been appointed by the Society to serve on the Advisory Committee of the International Association of Electrical Leagues, at the invitation of that organization's president, Herbert E. Cook. The IAEL is composed of member organizations encompassing the major divisions of the electrical industry. The Advisory Committee is set up to provide the association with advice from these branches of the industry to confer with the Board of Governors whenever problems involving their field shall arise.

Residence Lighting Forum Organized in Utah Section

The first meeting of the Residence Lighting Forum of the IES Utah Section was held February 2 in Salt Lake City. The meeting was attended by 27 representatives of dealers, distributors, architects, interior decorators and the utility. Featured speaker was Jean Brooner, an interior decorator, who spoke on "The Interior Decorator Looks at Lighting." This topic had been selected by the majority on a survey taken last December as being of particular interest.

Also as a result of the survey, the forum was held as a breakfast meeting, the time selected by most of the members as most convenient. This meeting time will be followed for future sessions which will be held in the first part of each month.

Officers of the forum include:

Evelyn Hansen, Chairman, Home Service Director, Utah Power and Light Co.
Thomas Felt, Secretary-Treasurer, Felt Electric Co.
Dale Brown, General Electric Lamp Division.
Leo Hansen, Westinghouse Lamp Division.

Engineers Conference Being Held At Ohio State University

The second Annual Conference for Engineers is scheduled for May 6, 1955 for alumni, faculty and students of the Ohio State College of Engineering to meet with engineers and architects from business and industry to review technical developments of the past year and look ahead to the coming year. In addition to offering the opportunity of participating in a continuation of last year's study and evaluation of engineering progress and prospects within and outside the College, the conference will provide opportunities for the meeting of engineers and architects from coast to coast.

The conference will open with registration, a general session, and a depart-

(*Continued on page* 11A)

LIGHTING CALENDAR

Society Events

March 31 - April 1, 1955 — Southern Regional Conference, Ft. Harrison Hotel, Clearwater, Fla.

April 3-5, 1955 — Southwestern Regional Conference, Gunter Hotel, San Antonio, Texas.

April 11-13, 1955 — Inter Mountain Regional Conference, Westward Ho Hotel, Phoenix, Arizona.

April 13-15, 1955 — South Pacific Coast Regional Conference, Statler Hotel, Los Angeles, Calif.

April 25-26, 1955 — Pacific Northwest Regional Conference, Harrison Hot Springs Hotel, Harrison Lake, B. C.

May 2-3, 1955 — Midwestern Regional Conference, Edgewater Beach Hotel, Chicago, Ill.

May 12-13, 1955 — Canadian Regional Conference, Hotel Mount Royal, Montreal, Que.

May 19-20, 1955 — East Central Regional Conference, Abraham Lincoln Hotel, Reading, Pa.

June 10-11, 1955 — Northeastern Regional Conference, Ft. William Henry Hotel, Lake George, N. Y.

September 12-16, 1955 — Illuminating Engineering Society, National Technical Conference, Hotel Statler, Cleveland, Ohio.

Industry Events

March 6-9, 1955 — National Electric Sign Association, Annual Convention, Biltmore Hotel, Los Angeles, Calif.

March 14-18, 1955 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 28-31, 1955 — Edison Electric Institute, Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

April 5-7, 1955 — Progress in Electrical Equipment Exhibit, Municipal Auditorium, St. Louis, Mo.

April 6, 1955 — Inter-Society Color Council, 24th Annual Meeting, Statler Hotel, New York, N. Y.

April 6-7, 1955 — Electrical Maintenance Conference, University of Southern California, Los Angeles, Calif.

April 17-22, 1955 — Society of Motion Picture and Television Engineers, 77th Semi-annual Convention, The Drake Hotel, Chicago, Ill.

April 18-21, 1955 — The American Society of Mechanical Engineers, Spring Meeting, Lord Baltimore Hotel, Baltimore, Md.

April 25-27, 1955 — National Association of Lighting Maintenance Contractors, Annual Conference, Henry Grady Hotel, Atlanta, Ga.

May 10-12, 1955 — Chicago Electrical Industry Show, Conrad Hilton Hotel, Chicago, Ill.

May 11-13, 1955 — Pacific Coast Electrical Association, Inc., Annual Convention, Palace Hotel, San Francisco, Calif.

May 12-13, 1955 — Public Utilities Advertising Association, Annual National Convention, Sheraton Hotel, Chicago, Ill.

May 22-25, 1955 — National Association Electrical Distributors, 47th Annual Convention, Conrad Hilton Hotel, Chicago, Ill.

June 13-16, 1955 — Edison Electric Institute, Annual Convention, Los Angeles, Calif.

June 13-22, 1955 — International Commission on Illumination (CIE), 13th Session, Zurich, Switzerland.

June 20-24, 1955 — American Society for Engineering Education, Pennsylvania State University, State College, Pa.

June 27 - July 1, 1955 — American Institute of Electrical Engineers, Summer General Meeting, New Ocean House, Swampscott, Mass.

June 13-15, 1955 — Western Plant Maintenance and Engineering Show, Pan Pacific Auditorium, Los Angeles, Calif.

August 15-19, 1955 — American Institute of Electrical Engineers, Pacific General Meeting, Butte, Montana.

September 25-28, 1955 — National Association of Electrical Distributors, Annual Convention, Pacific Zone, Empress Hotel, Victoria, B. C.

September 27-29, 1955 — Electrical Progress Show, Convention Hall, Philadelphia, Pa.

October 1, 1955 (Tentative) — Institute of Traffic Engineers, 26th Annual Meeting, Pittsburgh, Pa.

October 3-5, 1955—National Electronics Conference, Hotel Sherman, Chicago, Ill.

October 3-7, 1955 — Society of Motion Picture and Television Engineers, 78th Semi-annual Convention, Lake Placid Club, Essex County, N. Y.

October 3-7, 1955 — American Institute of Electrical Engineers (Fall General Meeting), Morrison Hotel, Chicago, Ill.

October 5-7, 1955 — Canadian Electrical Manufacturers Association (11th Annual Meeting), Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada.

October 11-14, 1955 — National Electrical Industries Show, 69th Regiment Armory, New York, N. Y.

October 17-21, 1955 — National Safety Council, 43rd National Safety Congress & Exposition, Chicago, Ill.

October 24-26, 1955 — 37th Annual Meeting and Sixth National Conference on Standards, American Standards Association, Washington, D. C.

October 30, 1955—Week of—National Electrical Contractors Association, Waldorf-Astoria, New York, N. Y.

November 1-3, 1955 — Fifth Industrial Electric Exposition, Hotel Wm. Penn, Pittsburgh, Pa.

November 2-5, 1955 — National Electrical Contractors Association, Annual Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 14-18, 1955 — National Electrical Manufacturers Association, Annual Meeting, Traymore Hotel, Atlantic City, N. J.

November 14-18, 1955 — Chicago Exposition & Power and Mechanical Engineers ASME, Chicago Coliseum, Chicago, Ill.

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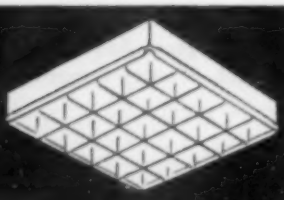

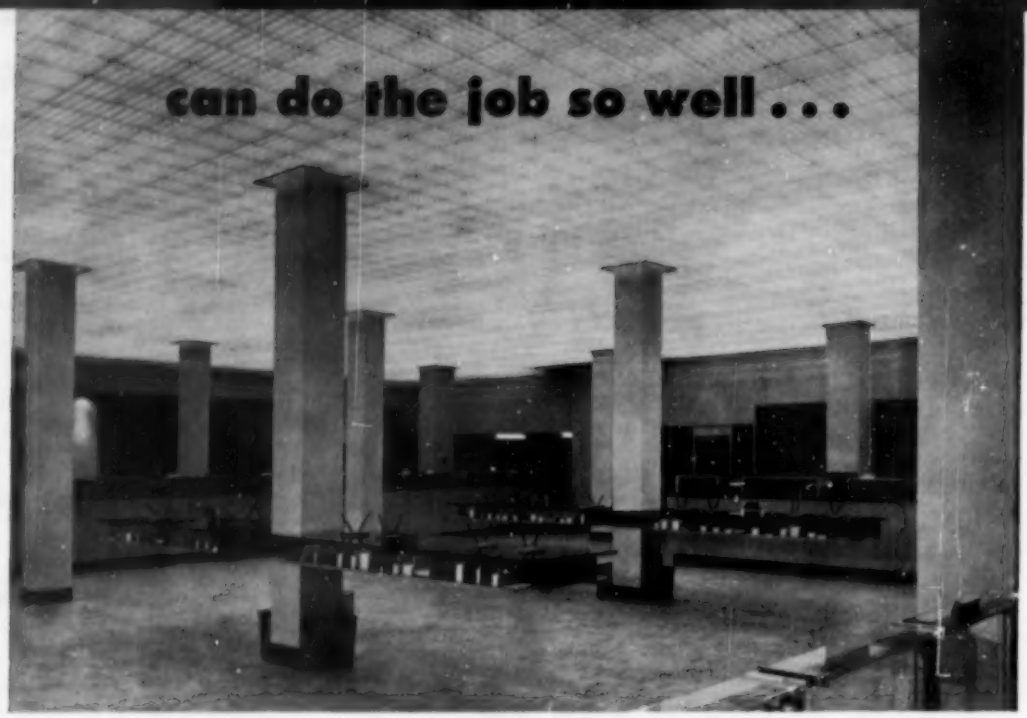

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LUVE-TILE is easy to maintain—dirt collection is much less rapid than with other types. . . and it will not hold insects and other small matter. Because LUVE-TILE is hinged, servicing of fixtures is easy. LUVE-TILE is also rigid to handle, light in weight and easy to remove and wash.

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Sprinklers and air ducts are concealed and wiring and other work may be simply surface mounted. Also low cost acoustic material may be sprayed on the cavity above the tile for sound proofing. LUVE-TILE is practical and economical to use in any area, right down to a few square feet. It is also widely used in display for special effects.

These Firms Were Concerned with the Industrial National Bank Building

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Contractor	Turner Engineering Company 470 Brainard, Detroit
Wholesaler	Michigan Chandelier, Company

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(Continued from page 9A)

mental technical meeting designed to help bring participants up-to-date on problems and developments of the day. Two of the speakers will be John C. Sharp, President of the Hotpoint Co., and General Curtis E. LeMay, Commanding General of the Strategic Air Command, USAF, both engineering alumni of the University. They will be followed on the program by college faculty and other experts who will discuss research progress in the college and demonstrate some of their projects and results. The evening will be devoted to an engineering Open House.

The Annual Conference for Engineers is under the direction of Gordon B. Carson, Dean of the College of Engineering. Associate Dean Harold A. Bolz is General Chairman of the conference.

Light in Architecture Subject of New York Exhibit

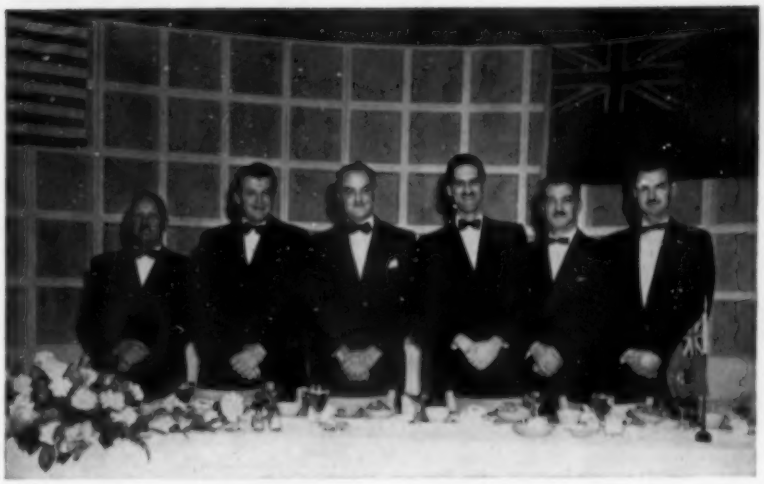
Examples of installations combining good lighting, good design, and imaginative application of both were displayed at a unique exhibition in New York January 18 through 28. Sponsored jointly by the Residence Lighting Forum, New York Section of I.E.S., and the local A.I.A. group, the exhibit featured huge photographic enlargements of some 50 installations, and samples of equipment used to achieve the successful lighting effects. The exhibition was staged at the Architectural League in New York, and was viewed by approximately 150 architects, designers and lighting specialists, on opening night alone.

Formal opening of the exhibition January 18 was preceded by a roast-beef dinner, also served at the Architectural League. Featured speaker at the dinner was Louis J. Kahn, prominent architect.

New England Section Honors President at International Banquet

On the occasion of their visit to Boston, February 8, President and Mrs. Duncan M. Jones were honored by the New England Section with a banquet which was, all together, a constructive I.E.S. meeting and a brilliant social event.

In addition to the I.E.S. President and his wife, other distinguished guests included the Consul-General of Canada (for all of the U. S.) Mr. Jean Fournier and Mrs. Fournier, and Mr. R. H. Tait, Canadian Consul in Boston, with Mrs. Tait. The Canadian guests were, of course, in honor of the first Canadian President of I.E.S. Among the 238 New England Section members who attended the affair were two Past-Presidents (Messrs. Julius Daniels and R. B. Brown Jr.); four Fellows (Charles Rex, Richard G. Slauer, W. P. Lowell, Jr., and R. B. Brown), the Northeastern Regional Vice-President C. W. McCormick, and three loyal and venturesome I.E.S. Members and their wives from nearby Connecticut Section (R. O. Mills, R. D. Babcock and Francis Clark).



FLAGS of two countries were hung at the President's Night Dinner of the New England Section, February 8, at the Fensgate Hotel, Boston, the Canadian flag in honor of the Consul General from Canada to the United States, the Consul to Boston and the Society's first Canadian President, Duncan M. Jones. Left to right are: Mr. R. H. Tait, Canadian Consul to Boston; Mr. C. W. McCormick, Northeastern Regional Vice-President; IES President Duncan Jones; Mr. Jean Fournier, Canadian Consul General to the U. S.; Mr. E. J. Perkins, New England Section Chairman; and Mr. W. K. Lewellen, Secretary Treasurer of the Section. Attendance at the gala meeting was 238 members and guests.

The interesting international flavor of the affair was heightened by the specially decorated room in which the dinner was held at the Fensgate Hotel in Boston. Flags of both Canada and the United States were furled behind the head banquet table, and toasts were proposed for President Eisenhower and Queen Elizabeth II. Mr. Fournier spoke of the warm feeling between the two countries, and particularly of the friendly reception he experienced in Boston. He then introduced his neighbor from Montreal, Quebec, Mr. Jones, who spoke of the influence of I.E.S. in both the United States and Canada on advances in Illumination, stressing especially the need for further support of basic research in lighting.

Prior to turning over the meeting to dancing, the guests were entertained by Mischa Tulin of Winthrop, who described and demonstrated the unique electronic musical instrument known as the Theramin. The visible portions of this device consist of an antenna and a loop. It is played by moving the hands in relation to the antenna, producing music much like that of a viola. The audience was captivated by the unusual demonstration. After the musical program, Edward O. Kassman of Westinghouse, costumed as a Town Crier of Colonial days, entered the hall ringing a bell and proclaiming "All's Well." This representative of olden days presented to Mr. Jones a Paul Revere silver cup, New England Sections traditional gift to honored guests.

January an Active Month For Michigan Section, IES

Special events — apart from the regularly scheduled January meeting — made this month an active one for the Michigan Section of IES. And the four speakers, using demonstrations, props, slides and a beautiful model, took the monthly Section meeting out of the ordinary class. The general topic of "Scanning the Broad Horizons of Commercial Illumination" was covered in the following way:

Today's Challenge in Store Lighting — James Finn.
Interesting Applications of Church and School Lighting — Alfred Sangster.
New Applications for Ultraviolet Radiation — Fred Ready.
Color in Illumination — Edmund Pratt.

(Continued on page 12A)

SOME of the many props used at the January 11 meeting of the Michigan Section are shown here with those participating in the program. Left to right are: James Finn, Fred Ready, Program Chairman Lee Tayler, Edmund Pratt, and Alfred Sangster, speaker and Regional Vice-President.

(Continued from page 11A)

The four speakers, all from Detroit Edison Co., were introduced by Program Chairman Lee Tayler.

EXTENSION MEETING

On the same date, January 11, the Section's Local Activities Committee held a meeting in Jackson, Mich., where the attendance of 21 architects, engineers, and representatives from utilities, manufacturers and wholesalers heard H. L. Logan, of the Holophane Co., speak on "Why Prismatic Control of Light?" Mr. Logan also discussed the place of visual comfort evaluation in the selection of equipment and of dimmage and distraction. Those attending were from Jackson, Battle Creek, Lansing, and Adrian, Mich.

STUDENT SEMINAR

The Section, through its Educational Student Membership Committee, also sponsored the third Annual Student Seminar, January 13 in the auditorium of the Kresge Science Library of Wayne University. The program featured the presentation, by the students, of solutions to an office lighting problem — a problem which had been submitted to the Detroit Edison Co. by a client. Students from the University of Detroit, University of Michigan, and Wayne University offered their solutions. J. J. Wilder, a senior electrical engineer from Wayne, showed a layout using a diffuse type fixture; and Harold J. Begrow, graduate architectural student from Michigan, presented his solution of a module-type luminous ceiling with built-in heating and sound-deadening facilities. James F. Finn, of the Section's Board of Managers, discussed the solutions, as compared to the one he evolved for the client.

The meeting was concluded by a talk on "The Psychological Approach to Store Lighting" by E. W. Miller of Detroit Edison Commercial Lighting Sales.

Some 60 students and members were present, including Great Lakes Regional V-P Alfred C. Sangster and Michigan Section Chairman Floyd Sell. Professor W. A. Hedrich represented the University of Michigan, Louis Kormendy the University of Detroit, and Professor Edward L. Fairchild, who is Chairman of the Educational Student Membership Committee, represented Wayne University. Other members of the Committee are Professor Hedrich, Professor R. W. Ahlquist and Donald E. Trefry.

Certified Lighting Program Inaugurated in Indianapolis

Indianapolis — the city in which a 1949 study indicated the need and opportunity for selling more industrial and commercial lighting — inaugurated a Certified Lighting Program on February 15, when the sales and technical training program began. The promotion and certification portions of the program will be put into effect soon, according to Albert L. Maillard, President and Managing Director of the Electrical League of Indianapolis, which is carrying out the program. Certified Lighting is sponsored by the National Lighting Bureau of the National Electrical Manufacturers Association.

IES Plans Sessions Of ISCC Annual Meeting

The afternoon and evening sessions of the 24th Annual Meeting of the Inter-Society Color Council, April 6, at the Hotel Statler, New York City, have been planned by a committee of the Illuminating Engineering Society. The morning session will be occupied by reports of the subcommittees of the Problems' Committee and the annual business meeting which will include reports of the officers and chairmen of the delegations from member bodies.

Four presentations are arranged for the afternoon:

How You See Colors — R. W. Burnham, Research Phychologist, Eastman Kodak Co.
Control of Moods and Atmosphere — Richard Kelly, Lighting Designer and Consulting Architect.
Color Timing in Merchandising — Mrs. Helen D. Taylor, Director of the Color Bureau, Tanners' Council of America.
Color at Work — Professor Edward Carswell, School of Architecture, University of Toronto.

In the evening a banquet will be held in the Skytop Room at the Statler. The speaker will be Ralph M. Evans, Eastman Kodak Co., who will discuss "Creative Directions in Color Photography."

Further details on this meeting may be obtained from Mr. Ralph M. Evans, Secretary, Inter-Society Color Council, Color Technology Division, Building 65, Eastman Kodak Co., Rochester 4, N. Y.

Industrial Lighting Forum Held By Green Bay Study Club

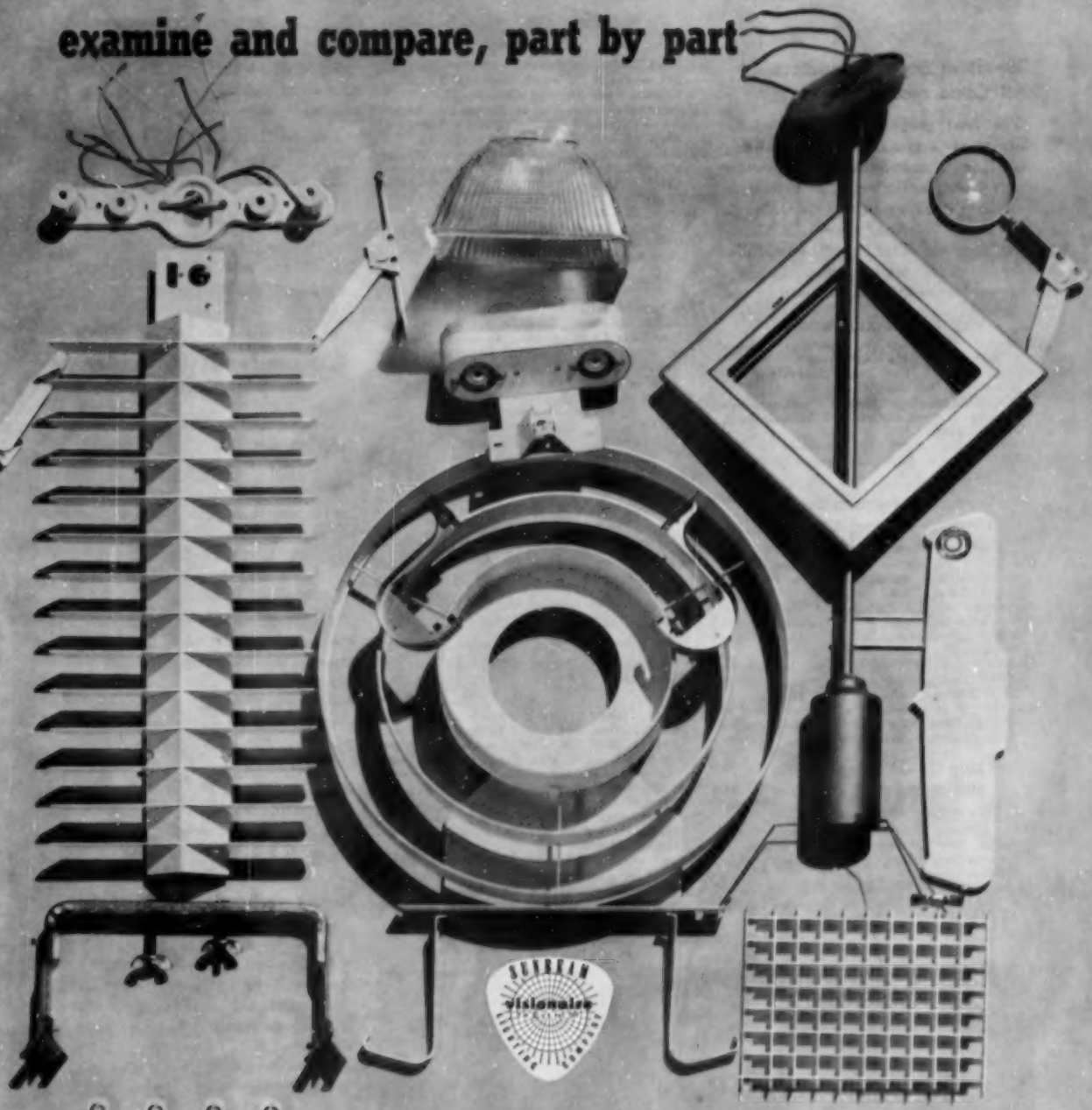
An attendance of 152 attests to the success of the Industrial Lighting Forum, held January 18 by the Green Bay (Wis.) Study Club. In addition to the architects, electrical engineers and utility representatives, this attendance included the maintenance engineers from manufacturers of aluminum goods, paper, cheese, and steel products. Study Club Chairman Rod Virgo presided.

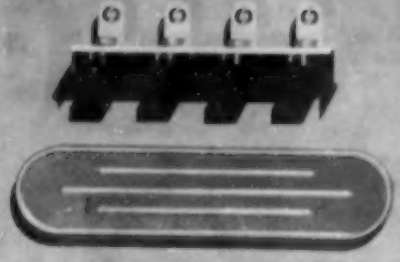
Speakers on the program were William B. Kennedy, District Engineer, Sylvania Electric Products, Inc., Milwaukee, who spoke on Industrial Plant Lighting; and R. F. VandenBoom, Lamp Division, General Electric Co., Milwaukee, whose topic was Lighting Maintenance. A stimulating question-and-answer discussion period followed the talks.

Credits for the interesting forum go to Study Club Chairman Rod Virgo; Program Committee Chairman, George Morrison, assisted by W. T. Dykema and R. T. Salzgeber; and Chairman of Extension Activities of the Milwaukee Section, Ralph Cheney. Refreshments were supplied by Wisconsin Public Service, in whose school room the meeting was held.

(Continued on page 14A)

examine and compare, part by part





Would you like to know how to *really* judge a good paint job on a lighting fixture? Write, on your letterhead, for a non-technical leaflet #EL18 on this subject.

We the engineers, designers, tool and die makers, welders, painters, assemblers; all of us at Sunbeam Lighting Company welcome with pride and confidence your critical examination of our work and products. Compare, part by part, a Sunbeam Visionaire® with another similar style and quality fixture. See for yourself our precision forming, clean welding, smooth, properly "aged" enamelling and other unexcelled examples of craftsmanship. Remember too, that only top grade steel and other materials are used in Sunbeam Visionaires®—and that all auxiliary electrical parts are E.T.L. tested and U.L. approved. Examine and compare. You will be convinced that quality Sunbeam fixtures are more economical in the long run.

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Midwestern Region Announces Final Conference Program

The final program for the two-day Midwestern Regional Conference, being held May 2 and 3 at the Edgewater Beach Hotel in Boston. The first three sessions will be opened by G. G. Boyd, Conference Chairman, while J. R. Chambers, Regional Vice-President will declare the final session open. Program and speakers will be as follows:

May 2 — Morning Session

Welcome — A. P. Larson, Chairman, Chicago Section, host to the Conference.
Address — J. R. Chambers, Midwestern Regional Vice-President.
My Most Interesting Lighting Job Contest — Regional Contest Chairman J. R. Chambers, and contestants.
LUNCHEON — Address by President D. M. Jones — G. G. Boyd, Conference Chairman, presiding.

May 2 — Afternoon Session

Brooks Chassaing, *Chairman*

St. Louis Section, presiding

Plastics in Lighting — W. E. Brown, P. C. Woodland and R. J. Lee, Dow Chemical Co., Midland, Mich.
Application of Floodlighting to Buildings — Benjamin S. Benson, Chief Illuminating Engineer, Benjamin Electric Mfg. Co., Des Plaines, Ill.
Modern Trends in Mercury Vapor Lighting — C. W. Craig, Lighting Engineer, Westinghouse Electric Corp., Chicago, Ill.
The 'Why's' of Ballasts — a Necessary Evil — Max D. Orr, Vice-President in Charge of Sales, Advance Transformer Co., Chicago, Ill.

May 3 — Morning Session

Don R. Schwarz, *Chairman*

Twin City Section, presiding

High Current Fluorescent Lamps — C. L. Amick, Coordinator of Product Planning of Fluorescent Lamps, General Electric Co., Cleveland, Ohio.
Application of 277- and 480-Volt Systems — J. B. Hodtum, Manager, Control Stations, Allis-Chalmers Co., Pittsburgh, Pa.
Subway Underpass Tunnels — Public Garages, Etc. — Frank D. Wyatt, Electrical Engineer, Chicago Park District, Chicago, Ill.
Maintenance — the Key to Economical Lighting — Gerald M. Marks, District Manager, Electro Silv-A-King Corp., Chicago, Ill.
Practical Methods for Measuring and Evaluating Lighting Systems — George Clark, Chief Engineer, Sylvania Electric Products Inc., Wheeling, W. Va.
LUNCHEON — Progress Report by E. W. Beggs, Westinghouse Electric Corp., Bloomfield, N. J. A. P. Larson, Chairman, Chicago Section, presiding.

May 3 — Afternoon Session

The Layman's Use of Glare Rating Systems — R. D. Bradley, Director of Engineering, Day-Brite Lighting, Inc., St. Louis, Mo.
The Influence of New School Design on Lighting — Lawrence B. Perkins, Architect, Perkins & Will, Chicago, Ill.
Your Marketing Challenge of the Future — Hoyt P. Steele, President, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Modern Aircraft Lighting — Southern California Field Trip

A two-part investigation on aircraft lighting was the feature of the January 19 meeting of the Southern California Section of I.E.S., held at the Los Angeles International Airport.

First on the program were talks by four experts on modern lighting for aircraft:

Lighting for Aircraft Exteriors (navigation, identification, and safety lighting)—William Bryant, Staff Engineer, Lockheed Aircraft.
Lighting of Aircraft Interiors (general lighting and passenger reading lights)—George Ledbetter, Luminator Corp.
Current Developments of Lamps for Aircraft Applications (higher intensity lamps to meet higher thermal requirements)—David Miller, General Electric Co.
Illumination for Landing and Taxiing Functions of Aircraft (practical aspects of illumination for adequate visibility during landing and taxiing)—Carlos Beeck, Lighting Engineer, Soderberg Manufacturing Co.

Featured at the dinner were displays of cockpit lighting equipment including panel and instrument lights.

The meeting then adjourned to the TWA Hangars for a flight over the airport and city to demonstrate the airport lighting facilities and point out, from the air, principal traffic safety lighting installations. About 80 of the 147 attending the meeting took the trip, at 3500 feet above the brightly lighted city.

I.E.S. Vice-President Attends Engineers Joint Council Assembly

A General Assembly of the Engineers Joint Council was held January 21, at the Statler Hotel in New York City, bringing together representatives from the country's engineering organizations particularly interested in the advancement of the profession. Representing the I.E.S. was Vice-President Marshall N. Waterman.

The program was made up of forum discussions on four main topics: Nuclear Engineering Developments, Employment Conditions and Unionization — Their Effect on the Engineer, Engineering Manpower, and Service Opportunities for the Engineers Joint Council. Dinner speaker was Donald A. Quarles, Asistant Secretary for Defense, Research and Development, whose subject was Engineers and Our National Well Being.

New York Section Sponsoring Ten-Week Lighting Course

A 10-week practical course covering the design of lighting installations for commercial and industrial applications, is being sponsored by the New York Section of I.E.S., with special attention given to layout technique and solutions to problems, consistent with I.E.S. recommended practices. The 1½-hour classes take place Monday evenings from February 28 through May 2, at the Consolidated Edison Building in New York City.

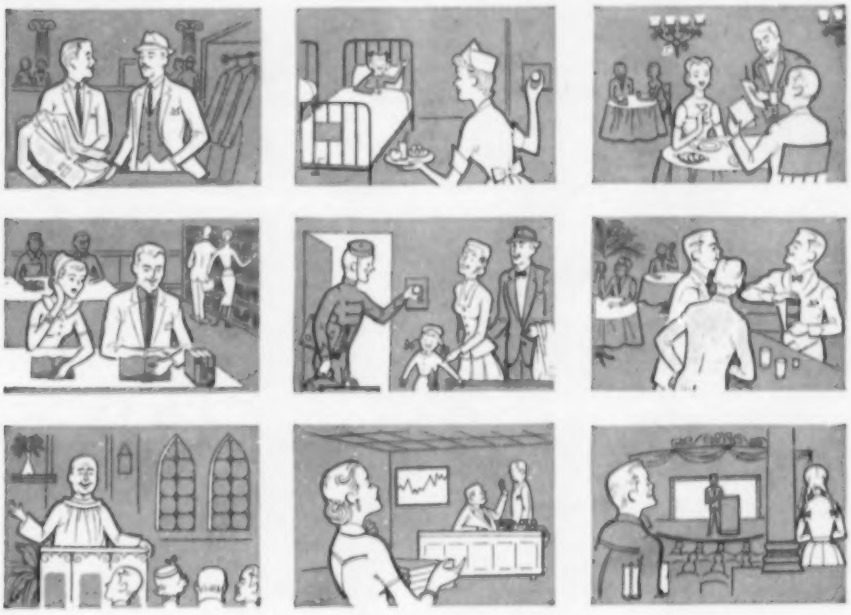
The IES Lighting Handbook is being used as the textbook for the course, which consists of these sessions:

February 28 — Interior Lighting Design; a review of methods for designing interior lighting applications.
March 7 — Design of Office and Classroom Lighting, Part I; quantity and quality of illumination for seeing comfort; classification of lighting systems; selection of equipment.
March 14 — Office and Classroom Lighting, Part II; design, layout, problems.
March 21 — Office and Classroom Lighting, Part III; problems involving typical practices in these areas.

(*Continued on page 16A*)

SOUTHERN CALIFORNIA FLIES AGAIN — Here some of the 80 members and guests who took the trip are shown aboard the TWA plane for a flight over the airport, the city of Los Angeles and suburbs to view lighting installations related to aircraft.

NOW...for those long-neglected applications



ANY LEVEL OF LIGHT FROM DARK TO FULL-BRIGHT

Here at last — for homes, hotels, churches, schools, restaurants, offices, stores — is a light control that makes sense. A light control that produces at the turn of a dial, any level of light from dark to full-bright, the perfect level of light for every occasion, every activity, every effect. New LUXTROL Light Control frees your layouts once and for all from the limitations of on-off lighting. It puts in your hands a whole new dimension in modern, functional design. A soundly engineered autotransformer-type unit — with brush and winding in constant contact and both fuse and thermal overload protection— LUXTROL operates smoothly, silently, safely, is approved by Underwriters' Laboratories. **No complex wiring required;** LUXTROL replaces ordinary on-off switches, is just as easy to incorporate in your plans. What's more, LUXTROL controls not only incandescent lighting but fluorescent and cold-cathode, too. And it's priced surprisingly low. Arrange a LUXTROL demonstration. Simply call Western Union Operator 25 in your own city and ask for the name of your LUXTROL distributor.

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(Continued from page 14A)

March 28 — Lighting for Store Interiors, Show Windows, Display Cases, Part I; general and supplementary practices; lighting needs for specific stores.
April 4 — Store and Window Lighting, Part II; layouts covering modern practices.
April 11 — Industrial Lighting, Part I; general designs for high and medium bay installations; localized and supplementary lighting; mercury, fluorescent and incandescent systems.
April 18 — Industrial Lighting, Part II; layouts and solutions to given problems.
April 25 — Industrial Lighting, Part III; problems of interior design; outdoor yard lighting; storage areas; protective lighting.
May 2 — General Review; review of design problems; lighting maintenance group replacement schedules; cost analysis.

This practical course was sponsored by the Section as a result of the numerous requests for an advanced course in lighting design and layout at the conclusion of the recent Fundamentals of Illumination course. Tuition is $10 for IES, AIEE or AIA members.

AIEE Sponsors Course on Lighting Wiring and Controls

A study group on New Wiring Methods and Controls for Lighting is being sponsored by the Illumination Division of the New York Section of the American Institute of Electrical Engineers, with weekly sessions for ten weeks, which started February 16.

Topics treated in the course are:

Study of Primary Distribution for Lighting.
Selection of Secondary Distribution for Lighting.
Electrical Characteristics of Light Sources and Auxiliaries.
Commercial and Industrial Lighting Equipment.
Lighting Layout.
Branch Circuits and Protection for Lighting.
Lighting Equipment Installation Methods.
Code Requirements for Lighting.
Estimating Costs.
Adequate Wiring Requirements.

Classes are being held in the Auditorium of the General Electric Co., 570 Lexington Ave., New York City. Registration for the entire course is $10 for members of AIEE or IES.

Two-Part Design Competition Underway in Cincinnati

The Ohio Valley Section of I.E.S. is currently sponsoring a design competition for architectural students at the University of Cincinnati. The problem is "An Apartment Building," with the design and development of the building stressing the dramatic use of light, and requiring at least one large scale detail of one of the lighting features.

Since the University Architectural course is on a cooperative basis (students going to school for seven weeks and working in industry for seven weeks), the competition is being held in two sections, and will have two problems and two prizes of $25 to the winners.

Individual instruction and assistance is being provided to the students by members of the Ohio Valley Section, which also arranged for a trip to the General Electric Co. Lighting Institute at Nela Park. The first section made this trip on January 13 and 14; the second section's tour is during March. Prizes will be presented to the winners at the April meeting of the Section.

The Section's Committee on Student Affairs, who arranged the competition, consists of Leonard P. Cohron and Robert W. Brown. Those at the University cooperating with the I.E.S. members on the project are Robert A. Deshon, Chairman of Architectural Design in the Applied Arts College and Ernest Pickering, Dean of the College.

ARCHITECTURAL students from the University of Cincinnati who entered the Ohio Valley Section's prize contest visit the G-E Lighting Institute at Nela Park.

Basic Lighting Design Course Presented in Western New York

A 6-week course in Fundamentals of Lighting Design attracted 48 registrants from the offices of local architects, electrical contractors and electrical wholesalers in the Western New York Section of I.E.S. last Fall.

Instructor for all sessions except #5 on Light Sources was J. F. Parsons, illuminating engineer with Niagara Mohawk Power Corp. Light sources in common use were covered by Willard E. Hayes, lighting engineer, General Electric Lamp Division; and Leo P. Gauthier, district engineer of Sylvania Electric Products Lighting Division.

A resumé of material covered in the six sessions is as follows:

#1 — Lumen method of lighting calculations and how to use the method.
#2 — More on the lumen method. Lighting terms and their understanding. Light measuring instruments and how to use them.
#3 — Quantity and quality. Planning for maximum comfort and seeing efficiency. Glare and how to control it.
#4 — Standards of illumination. The IES Lighting Handbook. American Standard Practices. How an understanding of these standards and their use in planning and selling helps in getting a better job.
#5 — Light sources in common use. Incandescent, mercury, and preheat, instant start, rapid start, slimline fluorescent. Effect of voltage, frequency, direct current, temperature, etc. Ballast characteristics. Group replacement, etc.
#6 — Equipment for general illumination. Distributions, types, limitations efficiency vs quality. Photometric reports.

Classes were held in the Electric Building auditorium in Buffalo, with two-hour sessions.

Office Lighting Clinic New York Section Project

Approximately 170 office management personnel took a one-day course in efficient office lighting practice in New York City January 25. The Clinic was sponsored by the New York Section of I.E.S. under the direction of L. R. Anderson, Chairman, and emphasized especially the value of good office lighting practice, and how to get it. Sessions commenced at noon and continued into the evening, with a recess for dinner.

Moderator for all sessions, held in the G. E. Auditorium, was Henry L. Logan, Director of Research for Holophane Co., Inc. An impressive "faculty" was featured in nine lectures followed by a question-and-answer panel which afforded an opportunity for the solution of a number of interesting problems. Lectures featured in the full-day clinic included:

Why We Need Good Seeing Conditions in Offices, Henry L. Logan, Moderator, Holophane Co. Inc., New York, N. Y.

(Continued on page 19A)

• CUNNINGHAM'S, DETROIT, is another outstanding example of Day-Brite store lighting. Installed on a sloping ceiling, in continuous rows on 10-foot centers, Day-Brite glass-enclosed Mobilex units maintain an average illumination of 65 footcandles.

Planned store lighting turns passers into buyers

NO MERCHANDISE is ever bought until the customer is "sold" on the idea of buying it. Sometimes he is already sold before he enters the store. More often, though, he is sold *after he comes into the store and looks around!* Obviously, therefore, getting customers *into* the store is the first step to sales.

Because store lighting is so important in turning *passers* into *buyers,* store owners all over the nation are turning to Day-Brite, where they are best served by store-lighting specialists. Starting originally in the field of store lighting, Day-Brite is now the nation's largest manufacturer of commercial and industrial lighting equipment.

Day-Brite specialists know store lighting—know how light should be used to stimulate store traffic and merchandise movement. Their recommendations are both sound and timely because they are based on the accumulated experience of 33 years.

Whenever you think of sales, call on Day-Brite. It's the name that means better selling through better lighting.

CALL IN A DAY-BRITE STORE-LIGHTING EXPERT! . . . SEE! EXAMINE! COMPARE! You'll choose Day-Brite fixtures because their superiorities are self-evident.

Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis 7, Missouri.

5427

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

NATION'S LARGEST MANUFACTURER OF COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

This electrical surge test is one of the 258 tests that every G-E ballast receives during the manufacturing cycle. This test subjects G-E ballasts to the most severe conditions they will ever encounter in actual operation; assuring you of long ballast life and low lighting costs.

Flora shows you why . . .*

Superior Quality Control of G-E Ballasts Helps You Save Lighting Dollars

Lighting engineers, designers, and users have learned to depend upon the consistently high quality of General Electric fluorescent lamp ballasts.

They know that the rigid material specifications and constant production line tests mean uniformly good ballasts; save lighting dollars by minimizing early replacement and maintenance costs.

Starting with raw steel and copper wire at the receiving dock and ending only when the finished ballast is loaded for shipment, G-E quality control engineers constantly test raw material and ballast parts to meet rigid mechanical and electrical requirements.

By actual count a G-E ballast receives 258 different tests and checks before packing and shipment! This painstaking care pays off to you in highly dependable operation, efficient lamp output, and long ballast life—it saves you valuable lighting dollars.

Next time you specify equipment for a fluorescent lighting installation, make sure you get the best...specify General Electric quality-controlled ballasts.

A G-E ballast tag or sticker on your fixture is proof that it's equipped with the best in ballast value. It's the easy way to be certain. For further information on G-E ballasts, write Section 401-9, General Electric Company, Schenectady 5, New York.

*Miss Fluorescent Ballast, G. E.'s Ballast Mascot

Copyright 1955, General Electric Company

CLOSE INSPECTION of each component assures you of high quality ballasts, lower lighting costs and dependable performance.

Five more reasons why

GENERAL ELECTRIC IS YOUR BEST BALLAST VALUE

- EXCLUSIVE SOUND RATING SYSTEM
- LONGER BALLAST LIFE
- PRECISE LAMP-MATCHED DESIGN
- PROVED PRODUCT LEADERSHIP
- COMPLETE CUSTOMER SERVICES

Progress Is Our Most Important Product

GENERAL ELECTRIC

(*Continued from page 16A*)

Trends in Office Building Architecture, by Douglas Haskell, *Architectural Forum* Magazine, New York, N. Y.
Ceiling Construction and Recessed Equipment, by Murray Quinn, Day-Brite Lighting, Inc., St. Louis, Mo.
Factors for Good Seeing Conditions, by W. S. Fisher, General Electric Co., Cleveland, Ohio.
Interior Surrounds, by George J. Taylor, Day-Brite Lighting Inc., New York, N. Y.
Electrical Distribution Systems for Office Buildings, by Howard D. Kurt, General Electric Co., Schenectady, N. Y.
Maintenance, by R. R. Wylie, Sylvania Electric Products Inc., New York, N. Y.
General and Drafting Room Office Lighting Tehniques, by John J. Neidhart, Westinghouse Electric Corp., Cleveland, Ohio.
Private Office and Miscellaneous Office Lighting, by W. S. Fisher, General Electric Co., Cleveland, Ohio.
What Price Comfort, by Henry L. Logan, Holophane Co., Inc.
Questions and Discussion.

All-Industry Wiring Design — 12-Week Course in Pittsburgh

A series of 12 weekly meetings, of two hours each, comprises a course on wiring design being sponsored jointly by the Pittsburgh Section of I.E.S. and the Electric League of Western Pennsylvania. The course is intended for builders, architects, designers, engineers, electrical contractors, distributors and manufacturer personnel. Subjects being covered in the meetings, which began January 31 and are held on Mondays each week, are:

1. Electrical Fundamentals
2. Electrical Formulas
3. Wiring Codes
4. Electrical Conductors
5. Electrical Systems
6. Parts of Wiring System
7. Wiring Materials
8. Designing the Lighting Wiring System
9. Residential Wiring
10. Commercial Lighting Wiring
11. Industrial Wiring
12. Industrial Wiring, continued.

Registration has been limited to 50 persons, with a fee for the entire course of $10. Classes are held in the General Electric Lamp Division office, 238 Carson St., Pittsburgh.

Scotland Is Site for British Extension Meeting

A special meeting, intended primarily for members in the British I.E.S. in Scotland and the four Northern Counties, will be held in Peebles, Scotland, May 6 and 7. The program planned will include a Presidential Welcome by E. C. Lennox; a lecture illustrated with pictures and sound by Monsieur J. J. Chappat of Paris on the light and sound spectacles in France; and a lecture by J. M. Waldram on trends in lighting practice.

Social activities will include afternoon tea with Mrs. Lennox at which there will be a mannequin parade presented by one of Edinburgh's leading stores.

ABOUT PEOPLE

A. I. Benedict was elected to the grade of Member Emeritus of the I.E.S. at the February meeting of Council. Mr. Benedict retired from the San Diego Gas and Electric Co. in 1950, at which time he was Engineer in Charge of Lighting. Through the formation of the Sight Saving Council of San Diego in 1935, he was instrumental in getting the first model classroom installed at San Diego State College. As a member of the Southern California Section of I.E.S., Mr. Benedict played an outstanding part in promoting the first regional conference in the South Pacific Coast in 1940. He also carried out an active part in the organization of the San Diego Chapter of which he is now a member.

M. D. Hooven, Public Service Electric and Gas Co., Newark, N. J., has been nominated as the 1955-1956 President of the American Institute of Electrical Engineers. The nomination was made during the five-day Winter General Meeting of the society January 31-February 4.

Curtis Lighting, Inc., announces the retirement of **G. T. Morrow,** Vice President in Charge of Sales. Mr. Morrow began his career with Curtis in 1922 and held several positions in the Sales Department, being appointed Vice President in 1940. Mr. and Mrs. Morrow will reside in Coral Gables, Fla.

Charles H. Goddard, I.E.S. Past President, has accepted a position with the Thomas A. Edison Co., West Orange, N. J., as Assistant Division Manager of the Voicewriter Division. Mr. Goddard, who assumed his new duties on February 9, has for the last ten years been with Sylvania Electric Products, Inc., where his most recent position was manager of utility sales.

Richard M. Smart has been appointed Midwest regional sales engineer for Sylvania Electric Products Inc., In his new position, Mr. Smart will be responsible for all phases of sales engineering in that region. A member of the executive board of the Cleveland Section of the I.E.S., he is also a member of the Board of Governors of the Cleveland Technical Societies Council. Mr. Smart will make his new headquarters at Sylvania's Chicago office at 2001 North Cornell Ave., Melrose Park, Ill.

Henry J. Chanon has been appointed marketing manager of the General Elec-Co.'s Outdoor Lighting department in West Lynn, Mass. Mr. Channon, who has been associated with the company since 1927, has been manager of Original Installation Sales at the Nela Park Lamp Division for the last three years.

PAUL REVERE BOWL, the New England Section's recently-adopted gift to an I.E.S. President, was presented to Past-President Julius Daniels on the occasion of Light's Diamond Jubilee. Mr. Daniels was Chairman of the Museum of Science Exhibit Committee of the Electric Institute of Boston for the Jubilee.

Solon E. Friedeberg of New York, associate of Sears and Kopf, mechanical and electrical consulting engineers, has been elected a national director of the National Society of Professional Engineers.

Appointment of **Dr. Herbert O. Rost** as chief development engineer of Jefferson Electric Co., Bellwood, Ill., has been announced. Dr. Rost, a native of Germany, joined the company two years ago as a research engineer. Jefferson also announces the appointment of **William J. Gorman** as merchandising manager. Mr. Gorman was formerly in the statistical research department of the Fibre Box Association.

Albert A. Fava has been elected President and appointed General Manager of Mobeco Inc., Watertown, Mass. Mr. Fava who is currently serving as President of the Engineering Societies of New England, has been associated with the New England Power Co., General Foods Corp., and Lumsden & Van Stone Co.

Wynn T. Sullivan has been named fixture advertising and merchandising manager for the Lighting Division of Sylvania Electric Products Inc., and

(*Continued on page 20A*)

(Continued from page 19A)

will make his office at the company's fixture headquarters in Wheeling, W. Va.

Sylvania Electric Products, Inc., also announces the promotion of **Willard L. Stiers** to the position of district manager, lighting sales, for the Chicago district, replacing **Frederick H. Heintz** who was recently promoted to Midwest regional sales manager. Mr. Stiers' former position as sales manager of the Kansas City district is being filled by **William C. Lounsberry, Jr.**, who has been a field representative for the Lighting Division.

Walter H. Thompson has been appointed Sales Manager of Kuhlman Electric Co.'s Western Transformer Division, to represent the company in the eleven western states and the El Paso area of Texas. Mr. Thompson has his office at 870 Tennessee St., San Francisco.

Three district sales managers have been named by Mitchell Manufacturing Co., Chicago. **August H. Jaeger**, Seattle, has been appointed to represent the company in Washington and Oregon; **Bertram E. Davidson** has been named New England sales manager for Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut; and **Burton L. Price** will cover the area consisting of Delaware, southeastern Pennsylvania, southern New Jersey and the Delmarva peninsula.

Rolfe Lee has been appointed by Stanford University, Palo Alto, Calif., as the Assistant for the Coordinated Classroom Laboratory and Seminar areas. His duties include preparation of information on principles and procedures demonstrated in the lab which is under direction of the School of Education.

The appointment of **Paul D. Johnson, James H. Cutter, George V. Sheppard, Jr.**, and **James W. Brooks, Jr.** as district representatives for General Electric's Construction Materials Division has been announced. Mr. Johnson has been assigned to the North Central District with his office at 531 West College Ave., Appleton, Wisc. Mr. Cutter will cover the greater Cleveland trading area with headquarters at 1817 Brookpark Rd., Cleveland. Mr. Sheppard has been assigned to Charlotte, N. C., and will have his office at 1300 Berryhill, and Mr. Brooks, in the Atlanta, Ga., area will have offices at 302 Red Rock Building in that city.

Two district managers were recently named by Electro Silv-A-King Corp., Chicago, Ill. **Hal P. Beard**, 800 Berry Rd., Memphis, Tenn., has been appointed for the territory of Arkansas, western Tennessee, and north and central Mississippi. **Albert R. Warren** will represent the company in central Illinois with his headquarters in Pekin, Ill.

Solar Electric Corp., Warren, Pa., announces a major reorganization of its Sales Department and has appointed **F. Leslie Watson** Vice-President in Charge of Sales, including promotion, representative agencies, direct sales, industrial sales and advertising. He joined Solar Electric from the executive staff of the Research Institute of America, Inc. Mr. Watson will make his headquarters at 501 Fifth Ave., New York, N. Y.

Marvin Manufacturing Co. announces the opening of a new factory and warehouse, located at 77-15 19th Rd., Jackson Heights, N. Y. The new factory is under the personal supervision of **Sam L. Beber**, President. **John Sankewich** has been appointed District Sales Manager and **Sid Klores** is Sales Engineer.

OBITUARIES

James M. Bennan, 44, president and chairman of the board of Jefferson Electric Company, Bellwood, Ill., was killed February 10 in an automobile accident. Mr. Bennan, son of one of the founders of Jefferson Electric Company, joined the firm in 1933 after his graduation from Loyola University. He became secretary in 1943, a vice-president in 1948, and president in 1949. In 1952 he was given the additional duties of chairman of the board of directors.

Mr. Bennan had been a director of the National Electrical Sign Association, and had served on the board of governors of the National Electrical Manufacturers Association since 1950.

H. Ward Zimmer, president of Sylvania Electric Products, Inc., died January 28 in New York Hospital after a brief illness. He was 57. He had served for 36 years with Sylvania, having joined one of the company's predecessor organizations in Emporium in 1919. He played a major role in the company's growth over the years, spending the greater portion of his career in the operations phase.

In 1947 he was named Vice-President in charge of operations and in 1950 became Executive Vice-President. He was elected President in April 1953.

Howard F. Ilgner, honored and beloved City Traffic Engineer and Superintendent of Electrical Services for the City of Milwaukee, died February 10 after a month's illness from a rare and unidentified virus. Mr. Ilgner, who was 65 at the time of his death, had been a member of the Illuminating Engineering Society, Milwaukee Section, since 1916.

A member of the I.E.S. Committee on Street and Highway Lighitng for more than 25 years, Mr. Ilgner had led in the development of Milwaukee's traffic control and street lighting systems, and was active in the traffic safety movement. He is credited with many "firsts" in the application of the principles of illuminating engineering to reduce traffic accidents.

Mr. Ilgner became ill early in January while attending a meeting of the National Highway Research Board, on which he was an active member. He was a member also of the Institute of Traffic Engineers, the National Joint Committee on Uniform Traffic Control Devices, the President's Highway Safety Conference, the American Public Works Association, and the Institute of Electrical Engineers.

Sections and Chapters of the Illuminating Engineering Society report with sorrow, the deaths of the following members:

F. Robin Adair, Philadelphia Section
Frank X. Chassaing, San Jacinto Section
Ben Clarkson, Alamo Chapter
Harold A. Sawer, Michigan Section

IT SEEMS TO ME

Membership Roster

The Society can render a real service to its membership at slight cost, or perhaps even a profit, if we will get out a Thirteenth Issue this year of ILLUMINATING ENGINEERING, to consist entirely of an up-to-date roster and advertising to help finance it.

Since such an issue would be kept (I hope not for *four* years as our present 1951 roster), it would have more than usual advertising significance.

So far as I am concerned, I would settle for devoting one of the *regular* monthly issues to a roster. This is the only organization to which I belong in which I cannot find currently a list of fellow members.

Change of jobs or addresses, deaths, new members, make our '51 roster woe-

(Continued on page 23A)

your ceiling planning comes to life with the new troffers

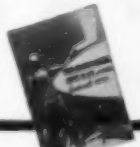
by Smithcraft

From drawing board to reality is now a simple transition in the creation of architecturally beautiful ceilings with recessed lighting. The new Smithcraft Troffer presents a clean, trim, uncluttered appearance because for the first time in troffer lighting *there are no visible catches, latches, bolts or screws.* Perfectly straight, trim, in-line rows free from light leaks or blemishes are formed with new Smithcraft Troffers which are *architecturally precise modules for exactly 12" openings.* Adaptability to today's ceiling constructions is virtually universal *(a single simple clip adapts the Smithcraft Troffer to most ceiling conditions and simple provisions are made for all others.)* A new flexibility of design is provided through the *widest possible choice of shielding media, pattern lighting methods and accenting troffer boxes.*

This mounting bracket with simple clip attachments adapts the Smithcraft Troffer to a great majority of the ceilings in use today.

The new Smithcraft troffer-in-plaster frame method assures perfectly square plastered openings and is unbelievably simple to install.

Write today for the new Smithcraft Troffer Book illustrating and describing the new Smithcraft Troffers in detail.



Door frame containing glass, plastic or lens instantly opens or closes by simple pressure upwards.
In louvered units, louvers hinge from either side and are removed without tools or loose parts.
Smithcraft
LIGHTING DIVISION

"BUY LIGHTING" — *NOT FIXTURES* — INVEST IN AMERICA'S FINEST FLUORESCENT LIGHTING

PRIVATE OFFICE: Campbell-Mithun Agency, Northwestern Bank Building, Minneapolis, Minn.

AGENT: North Central Electrical Distributors

1st PRIZE
SCHOOLS AND OFFICES CLASSIFICATION
Lighting Competition Sponsored by
ELECTRICAL CONSTRUCTION & MAINTENANCE
NOTE: 1st, 2nd and 3rd prizes in this classification were all won with Wakefield equipment.

WAKEFIELD SIGMA IN A PRIVATE OFFICE

by *JOHN KVALSTEN ELECTRIC COMPANY*

"The color scheme in this office is a natural colored burlap wall with blue draperies and a cream ceiling. Furniture is in walnut with varied colors of upholstering. Carpet is beige.

"For a beam ceiling effect, one of the most recently developed luminous ceiling elements with vertical acoustical baffles was used.

"Six Wakefield Sigma units were used to provide a high level, low brightness illumination with the beamed ceiling effect. The arched plastic diffusers are mounted on hinges with a touch latch catch. The maintenance features are particularly desirable.

"Twelve 96" T12, 430 MA de luxe and de luxe cool lamps (six each) were used behind the panels. Each color is switched separately to provide a variation of color environment.

"80 footcandles are maintained on the desk top with an average maintained in the room of 70 footcandles. The luminous ceiling has a brightness of 220 footlamberts, the baffle 50 footlamberts, the ceiling 10 footlamberts, the wall 25 footlamberts, the floor 15 footlamberts."

For a new catalog on the Wakefield Sigma, as well as other Wakefield Geometrics, write to The F. W. Wakefield Brass Company, Vermilion, Ohio. In Canada: Wakefield Lighting Limited, London, Ontario.

Wakefield Congratulates JOHN KVALSTEN ELECTRIC CO.

WAKEFIELD

VERMILION, OHIO LONDON, ONTARIO

(*Continued from page* 20A)

fully inadequate for ready exchange of illumination data.

The purpose of the Society is interchange of knowledge. Lack of a current list of members puts up a real barrier to that highly desirable objective. T. D. WAKEFIELD, *Vice-President, The F. W. Wakefield Brass Co., Vermilion, Ohio.*

Abstracts From Foreign Lighting Journals

The following abstracts of articles in German and French lighting publications were prepared by Frank J. Vodicka, a long-time member of I.E.S.

"Emission Spectrum of Fluorescent Lamps for Blueprinting and Similar Reproduction Processes." Dr. I. Henze, *Lichttechnik*, p. 359-360, October 1954. In German.

Types of fluorescent lamps suitable for reproduction processes employing light sensitive papers are described. Spectral distribution of the fluorescent lamps and the actinic part of their spectra are compared with the spectral sensitivity of the paper used for reproduction, in order to define the efficiency of the reproduction process.

"Economics of Lamp Replacements." Dipl. Ing. F. Ziegler, *Lichttechnik*, p. 395-398, November 1954. In German.

The economic problems of single lamp replacement against group replacement are analyzed and formulas and graphs shown which give cost of replacement under various operating conditions. Concept of optimum cost of replacement is developed and formulas and graphs for evaluation of these costs given. The optimum cost of lamp replacement is broadened to include the effect of loss of illumination due to aging of lamps and accumulation of dirt. Application of the formulas and graphs for solution of practical operating problems is demonstrated.

"Color of Light for the Workshops of the Printing Industry and Illumination for Inspection of Colored Prints." Dr. W. Bartholomeyczyk, *Lichttechnik*, p. 323-325, September 1954. In German.

Quantity and quality of illumination for printing shops in general and for inspection of color work in particular are discussed. Recommended illumination values are given. A color inspection booth is described and a construction drawing and wiring diagram shown. Sources of illumination are discussed including the xenon lamps and spectral distribution diagram of these sources is included. The use of monochromatic light for production line inspection is discussed. Related bibliography is appended.

"Experimental Light Measurements with Preset Spectral Sensitivity of the Receiver." H. Korte and M. Schmidt, *Lichttechnik*, p. 355-359. October 1954. In German.

An experimental method for spectral analysis is described in which a spectrograph was used with reversed direction of light so as to obtain a preset spectral sensitivity of the spectrograph and multiplier. For intensity control as a function of wavelength, cutouts and sector discs were used. Sensitivity of the receiver and the corresponding light control produced a preset spectral distribution. An experimental setup using optical elements and filters with a spectral sensitivity variable within certain limits is described.

"Elementary Theory of Luminaires with a Curved Reflector and Point Source." J. Dourgnon, *Lux*, p. 76-78 and p. 95-97, October, November 1954. In French.

The article gives a development of basic formulas for calculation of illumination produced by luminaires with curved reflectors and using a point source. The difference between exact values at given points and approximate values obtained by means of the inverse square law is discussed. The influence of the size of source as it deviates from a point source on the theoretical value of illumination at a given point is shown.

I.E.S. National Technical Conferences

1955 — September 12-16 — Hotel Statler, Cleveland, Ohio

1956 — September 17-21 — Hotel Statler, Boston, Massachusetts

1957 — September 9-13 — Biltmore Hotel, Atlanta, Georgia

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario

BOOKS AND PAMPHLETS

Engineers' Job Directory is a new annual publication, designed to help the engineer investigate the better job market. Published by Decision, Inc., the directory lists information supplied by the companies participating on industry, year founded, products, number of employees, and whom to contact, to enable the engineer to coordinate and match his interests and capabilities with the company. An index section includes types of engineers needed, and plant, sales, and research laboratory locations. Copies may be obtained for $2.25 from Decision, Inc., 105 East Fourth St., Cincinnati 2, Ohio.

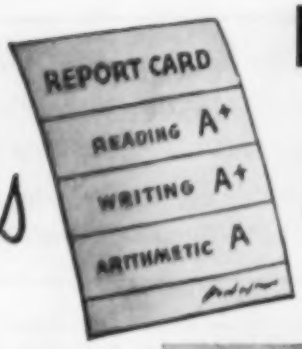
Construction Review, a joint monthly publication of the U. S. Department of Commerce and the U. S. Department of Labor, presents the major statistics in the field of construction compiled by the Federal Government and some private sources. The introduction to the first issue, January 1955, states plans for articles on specific aspects of construction, including interpretation of trends, outlook, and special studies. This first issue consists of the following sections: Introduction; At a Glance, a resumé of news; a feature on Construction in 1954; Construction Put in Place, a breakdown of the current month by type of construction; New Housing; Building Permits; Contract Awards; Costs; Materials; Employment; Explanatory Notes, and Index. The material is presented in tabular form and by line drawings. *Construction Review* is available at $3.00 per year Domestic and $4.00 Foreign from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Bibliography on Unionization of Professional Engineers has been prepared by the Engineering Societies Library to answer inquiries received by the Library from engineers, engineering students and others interested in the subject. The 100 references in the bibliography are to pamphlets and articles in magazines from 1937 to 1954, which are in the Engineering Societies Library. ESL Bibliography No. 10 is eight mimeographed pages, available from the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y., at $2.00.

I Want To Know About the Electric Industry, 1954-1955 edition, has just been published by the Edison Electric Institute. This year's edition, the seventh in a series begun in 1948, discusses in some detail the industry's record growth in recent years, the financial investments which made this growth possible and future prospects for continued expansion, extending as far ahead as 1975 and including a discussion of the possibilities of a transition from the use of ordinary fuels to nuclear energy in the production

(*Continued on page* 30A)

BETTER LIGHTING assures better learning



MEYERS PARK HIGH SCHOOL
Charlotte, N. C.

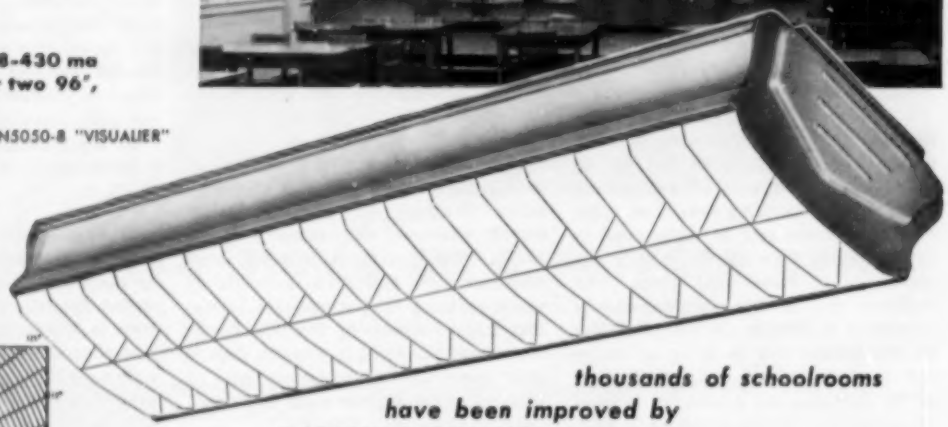
Architects-Engineers:
J. N. Pease & Company
Charlotte, N. C.

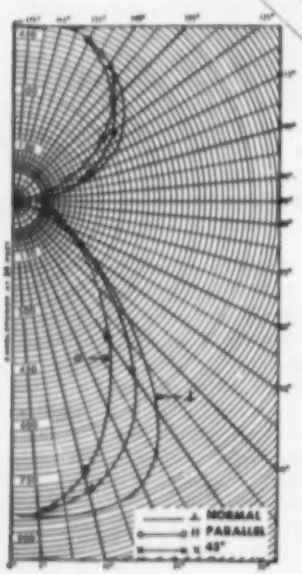
Distributor:
General Electric Supply Corporation
Charlotte, N. C.

Electrical Contractor:
Austin Electric Company
Charlotte, N. C.

Using Garcy SL5050-8-430 ma (Louvered fixtures for two 96", T-12 Slimline lamps)

Illustration shows GARCY SLN5050-8 "VISUALIER" for Slimline lamps . . . Also available in 4' units for fluorescent or slimline lamps, individual mounting or continuous runs. Four lamp matching fixtures also available.





thousands of schoolrooms have been improved by GARCY'S "VISUALIER"

Schoolroom lighting installations, once completed, have a way of staying on for many, many years. It is doubly important, therefore, to obtain the right fixture in the first place. Garcy's Visualier is eminently qualified. Lighting efficiency far exceeds I.E.S. and A.I.A. school lighting specifications . . . as to light utilization, light distribution, shielding and low surface brightness. And of equal importance, high level lighting efficiency can be readily maintained. The large louver cells are easily cleaned from the floor with a brush or vacuum. All-metal construction means no breakage or warping. Detailed literature and E.T.L. data sent on request.

New Garcy Lighting Equipment Catalog Now Available

GARCY

GARCY lighting equipment

GARDEN CITY PLATING & MFG. CO.
1760 North Ashland Avenue
Chicago 22, Ill.

in our plazas,
parking areas, shopping centers and drive-ins
NEWARK AIRPORT
P & K Double and Single Tapered Elliptical Arm type standards installed here have 25 foot mounting heights, TB-2 Transformer Bases and 12 foot arms. Four 20 foot floodlight poles with twin projector assemblies are also installed. They are in perfect harmony with Newark Airport's recently modernized appearance and efficiency.

the P&K story

in our communities . . .
LEVITTOWN, PENNSYLVANIA
Scheduled for completion by the end of 1954, Levittown, Pa. will be the state's tenth largest city! Its streets will feature modern, efficient lighting provided by more than 4,000 P & K All-Aluminum Standards and Brackets: 20 foot pendant type with P & K Tapered Elliptical Lighting Arms.

on our highways . . .
THE NEW JERSEY TURNPIKE
Looking toward Laurel Hill and the Lewandowski Bridge crossing the Hackensack River. The P & K All-Aluminum Standards on Transformer bases have 30 foot mounting heights with 15 foot All-Aluminum Tapered Elliptical Arms. They are installed at all interchanges, bridges and service areas along the entire highway.

P & K ALL-ALUMINUM STANDARDS AND BRACKETS ARE PRODUCED IN DESIGN AND TYPE TO MEET *EVERY* ROAD, HIGHWAY, AREA OR FLOOD LIGHTING REQUIREMENT.
They are always the wisest investment for both efficiency and economy:

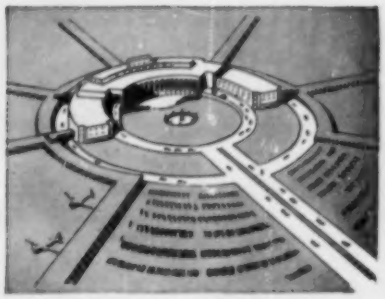
- Much lighter weight for easy handling and low cost installation
- Negligible rate of corrosion for longest service life
- No painting means initial and year-after-year saving
- Easily salvaged and re-used in event of knockdown

WRITE FOR LATEST P & K CATALOG . . . and use the P & K planning and advisory services without obligation.

Pfaff & Kendall
84 Foundry Street
Newark 5, New Jersey

*Lighting that makes the nation's most important buildings come alive

EMPIRE STATE BUILDING, N. Y. C.



IDLEWILD INTERNATIONAL AIRPORT, NEW YORK

CONSOLIDATED EDISON CO., N. Y. C.

DETROIT INSURANCE AGENCY, DETROIT, MICH.

SOME OF THE IMPORTANT ORGANIZATIONS NOW USING PHILITE SERIES 1118 or SERIES 1119 LUMINAIRES.

American Reinsurance Company
Committee for Free Europe
Continental Casualty Co.
City Hall Annex, Philadelphia
Loft Candy Shops
Mepham Junior High Schools
National Banks of Detroit
New England Telephone Co.
Norden Instrument Co.
Speed Products Corp.

When fine lighting is required for either original installations or for modernization programs, more often than not the nation's leading organizations select Ruby-Philite luminaires. And for good reason. Ruby-Philite luminaires are designed to provide high levels of illumination with maximum efficiency and comfort, engineered for lowest installation and maintenance costs, and constructed to withstand hard usage. **Write today for complete catalog data.**

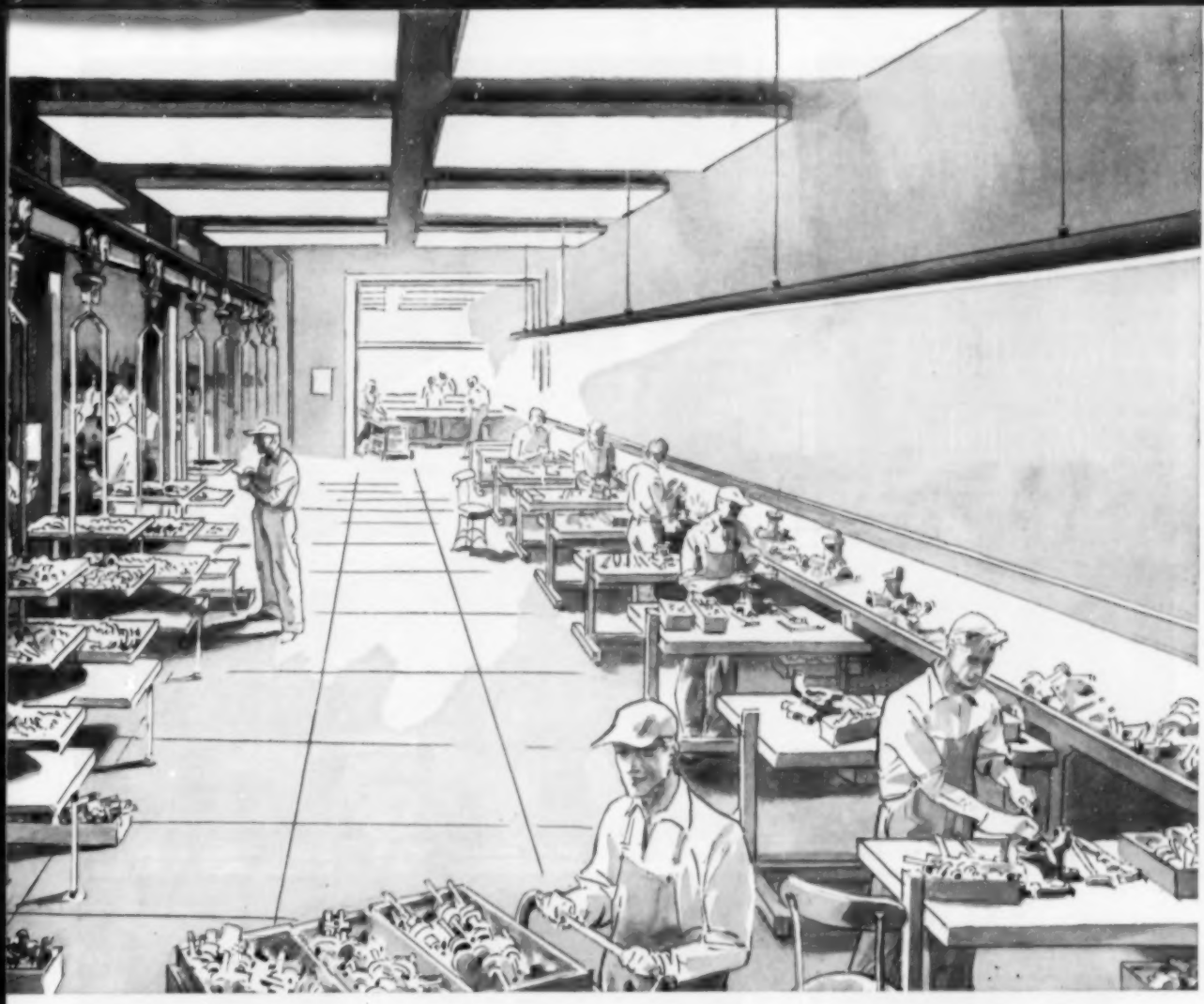
*PHILITE SERIES 1118 & PHILITE SERIES 1119 • Commercial luminaires with illuminated metal or translucent plastic sides available with choice of metal louver, plastic louver, or extruded plastic shielding.

PHILITE

MEMBER R.E.M.A.

Ruby-Philite Corp.

32-02 QUEENS BLVD., LONG ISLAND CITY 1, N. Y.



9:3:1—the light ratio for peak work efficiency

Specular glare and shadows now eliminated with diffusers of extruded Du Pont LUCITE® acrylic resin

Workers perform tasks with greatest accuracy, speed and comfort under well designed lighting conditions. Lighting engineers have established that a brightness ratio of 9 at light source to 3 at task area and 1 at background is the best lighting environment.

Diffusers of Du Pont "Lucite" effectively assist in achieving this ideal ratio. Extruded sheets and panels of this durable engineering material transmit optimum light while eliminating reflected glare and shadows. The rated lumen output of properly maintained fixtures of translucent white "Lucite" remains essentially constant through years of service, and they resist discoloration and weathering.

Complete information on lightweight "Lucite" is available on request. Write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 283 Du Pont Bldg., Wilmington 98, Del.

A four-foot-square modular unit formed from extruded "Lucite." Its permanence and lasting beauty allow years of low-maintenance performance. These panels resist discoloration and outdoor weathering through years of service.

Extruded "Lucite" allows flexibility of design to meet custom specifications. "Lucite" has excellent shatter resistance, color stability and blends harmoniously with other materials used.

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Unheard-of flexibility for you: Fixtures may be mounted on the Uni-Race in continuous rows, or spaced at intervals of 4', 8' or 12'. They can be moved about, or additions made, as conditions demand without further electrical work and without interrupting service. Repairs or replacements are made by changing fixtures without disturbing other fixtures on the circuit.

Write Today . . . for brochure giving complete details of the remarkable new Ortho-88. In addition to installation and mounting data, it illustrates several examples of how Ortho-88 versatility can work for you. Catalog pages giving complete engineering data are included.

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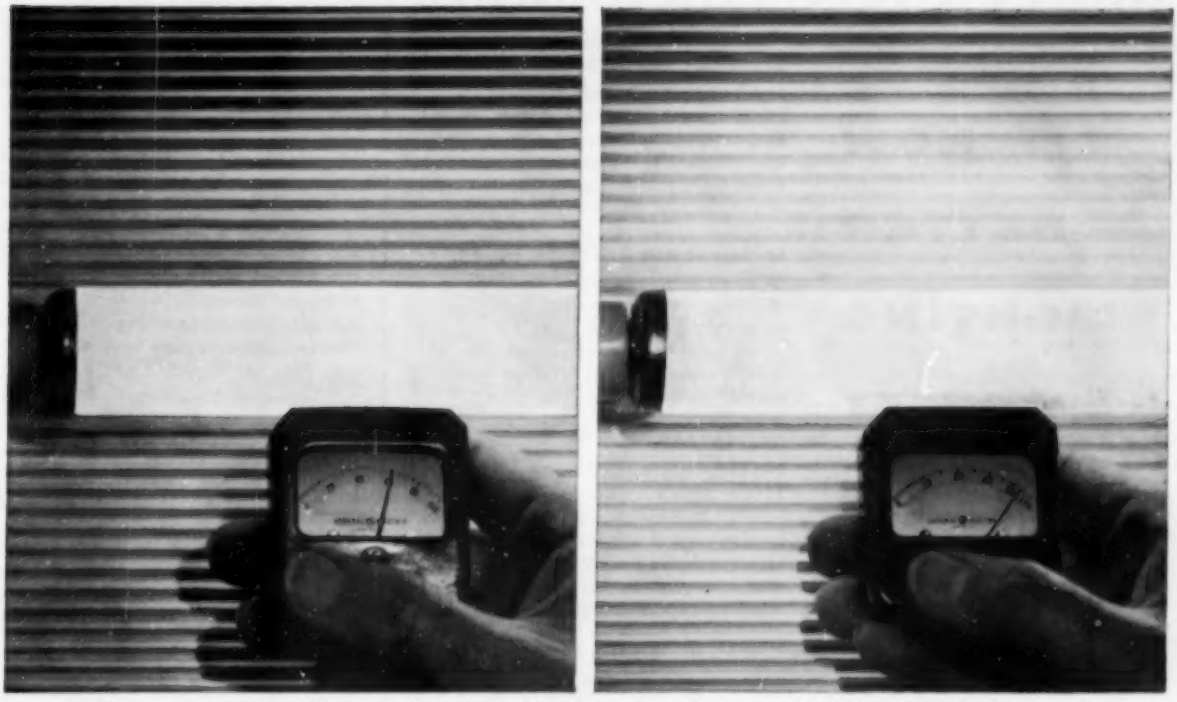

Photos above show relative difference in light output of regular slimline, left, and New High Output Rapid Start lamp, right.

NEW GENERAL ELECTRIC FLUORESCENT LAMP GIVES ⅓ MORE LIGHT THAN ANY PREVIOUS FLUORESCENT

LIGHTS ALMOST INSTANTLY—General Electric announces the most important advance in fluorescent lighting in 10 years: the new High Output Rapid Start fluorescent lamp. The 96-inch High Output lamp gives 36% more light than the most powerful G-E fluorescent lamp previously available.

For new installations, General Electric High Output lamps offer this ⅓ bonus of light without increasing the number of fixtures or maintenance costs.

This big increase in light, with no increase in lamp size, has been achieved through a special cathode developed by General Electric which permits a boost in lamp wattage to 100. Because the cathode is of the famous General Electric triple coil design, these Rapid Start lamps light up almost instantly. General Electric High Output lamps have a rated life of 7,500 hours, the same as all General Electric general lighting fluorescent lamps.

A new G-E base and socket design protects the lamp contacts by recessing them. A simple push-pull sets the lamp in its fixtures.

HAS VARIETY OF USES

The new General Electric High Output fluorescent lamp is especially suited for use in areas with high ceilings, in factories, warehouses, offices and stores. Also in store windows, showcases and other places where you want higher lighting levels in keeping with the modern trend. New fixtures designed for the G-E High Output lamp will soon be available from a number of lighting fixture manufacturers.

For information, write to Lamp Division, General Electric Company, Dept. 166-1E-3, Nela Park, Cleveland 12, Ohio.

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Skylume provides 75% Uplight and 25% Downlight to achieve an unusually low brightness contrast ratio. Even with higher lighting levels, this properly diffused illumination eliminates glare so as to provide exceptionally comfortable lighting.

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SKYLUME IS AVAILABLE IN:
Rapid Start and Slimline (Standard also available) 2 ft.-4 ft.-8 ft.—2 lamp, 3 lamp, 4 lamp.

- Styrene with 15% transmission factor is standard. Plexiglass also available . . . as well as enclosures with higher transmission factors for surface mounting. All open from either side for easier maintenance.
- All models have continuous wireways for interconnected units.
- "Lite-Gard" Fuse which isolates individual fixtures against thermal and electrical overload available with all models.

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Electro Silv-A-King Corporation

1535 South Paulina Street, Chicago 8, Illinois

Spruce & Water Sts., Reading, Pennsylvania

DESIGNERS AND MANUFACTURERS OF THE FINEST IN LIGHTING

(Continued from page 23A)

of electricity. The booklet is presented in the form of 28 questions frequently answers in text-and-table-form, derived asked about the electric industry with from such sources as EEI's annual Statistical Bulletin and various Federal Power Commission publications. The use of electricity in the home, on the farm and in industry and commerce; source and disposal of electric company revenues, steam plant and water power installations, and ownership trends of generating installations are among the subjects discussed. The 32-page booklet is available from the Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, February 10, 1955, the following were elected to membership. Names marked * are transfers from Associate Member grade.

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Jarrell, B. N., Graybar Electric Co., San Antonio, Texas.

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Walker, T. W. H., Canadian Westinghouse Supply Co., Ltd., Vancouver, B. C.

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Warren, A. R., Electro Silv-A-King Corp., Pekin, Ill.

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Dani, R. C., Joslyn Mfg. & Supply Co., Chicago, Ill.
Frederickson, C. J., Jr., Joslyn Mfg. & Supply Co., Chicago, Ill.
Meyer, H. J., Lighting Equipment Co., Chicago, Ill.
Smaller, S. E., Schmidt, Garden & Erikson, Chicago, Ill.
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Truske, T. N., University of Illinois, Urbana, Ill.
Vaulman, R. M., University of Illinois, Champaign, Ill.

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White, K. E., Jr., Westinghouse Electric Corp., Cleveland, Ohio.
Worley, R. L., Westinghouse Electric Corp., Cleveland, Ohio.

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Becker, E. K., The Superior Electric Co., Bristol, Conn.

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Jensen, K. G., Interstate Electric Supply Co., Council Bluffs, Iowa.
Johnson, H. P., Consumers Public Power Dist., Norfolk, Nebr.
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Dettmore, G. J., Pennsylvania Power & Light Co., Wilkes Barre, Pa.
MacMillen, J. W., Pennsylvania Power & Light Co., Williamsport, Pa.
Reeves, T. K., Pennsylvania Power & Light Co., Allentown, Pa.
Scutt, D. C., Eastern Engineering Co., 836 Elm, Reading, Pa.
Stanley, P. H., The Miller Co., Meriden, Conn.

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Staples, W. J., Suburban Electric Co., Malden, Mass.
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Winslow, F. E., Smitheraft Lighting Division, Chelsea, Mass.
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(Continued on page 32A)

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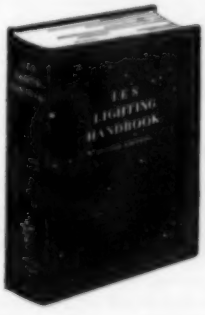

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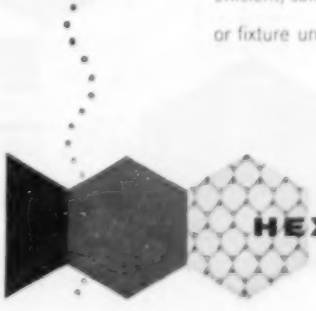

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